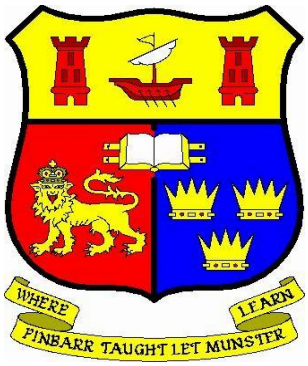
A CODE TOWARDS GREATER SAFETY IN THE LABORATORY

SAFETY MANUAL

Undergraduate, Postgraduate Students and Staff

2010-2011

Molecular Virology, Department of Medicine,
University College Cork



In accordance with the Safety, Health and Welfare at Work Act 1989, it is the policy of Cork Institute of Technology and University College Cork to ensure, so far as is reasonably practical, the health and safety while at work of all employees and students. The successful implementation of this policy requires the full support and active co-operation of all employees and students.

If you have any queries, accident/incident reports, hazardous situations, please contact your supervisor:

List of Molecular Virology Departmental Allocated Project Supervisors

Supervisor Name	Supervisor Contact email	Tel	Location
Dr. Liam Fanning	l.fanning@ucc.ie	021-4901281	CSB, UCC

Outside of normal working hours, please inform Security Personnel, who can contact staff on your behalf.

Important Telephone Numbers:

Security Desk UCC: 021 4902266
Cork City Fire Brigade, Anglesea Street: 999 or (021) 4966333
Garda: 999 or Cork City MacCurtain St, Tel: (021) 4503337
CUH Wilton: (021) 4546400 OR 49522554/2 (MVDRL office/lab)

Departmental Safety Representative in Department of Medicine Ms. Jacqueline Kelly; Tel (021) 4901229

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A CODE TOWARDS GREATER SAFETY IN THE LABORATORY

1.0 Introduction

This manual, entitled 'A CODE TOWARDS GREATER SAFETY IN THE LABORATORY' (hereinafter 'The Code' or 'Safety Manual') is offered as a general guide to safer working in laboratories. By its very nature, it cannot hope to be a comprehensive or definitive set of regulations or codes. Its implementation requires the common sense, skills and experience of all staff (Academic Staff, Research Associates, Post-doctoral Fellows, Technicians, Demonstrators, Postgraduate Students, Undergraduates, Visiting Fellows, Executive Assistants, etc.) before it can be usefully applied to each situation. Responsibility for the instruction and training of all staff and students in health and safety aspects of work in that Department or Units rests with the individual Supervisors and ultimately with the Head of Department.

This abridged version is specifically for 4th year undergraduate students.

2.0 Responsibility

2.1 Safety/Security Features To Note In Your Work Area

When you arrive in the Department and are assigned a position in the laboratory, make yourself aware of the following:

[a] Emergency exit positions and routes

[b] Gas and water mains taps in your vicinity

[c] Positions of and use of fire blankets and fire extinguishers

[d] Position and contents of first-aid cabinets

2.2 Responsibility in the Laboratory

Responsibility for safety in each Department or Unit within the Faculty rests with the Head of Department, who may delegate but cannot relinquish this responsibility and must make every reasonable effort to ensure that those with delegated responsibility are made known to persons at work in the Department.

All persons with responsibility for safety are required to nominate suitable persons to act for them when they are absent on leave or because of long illness, and must inform the Head of Department and the Departmental Safety Officer.

The Safety Committee is the body to which Heads of Department are immediately responsible in matters of safety administration.

Heads of individual laboratories can ensure that:

[a] Laboratories and other work places, their equipment and other facilities are suitable and properly maintained for the safe conduct of the work.

[b] There is a sufficient number of trained staff, properly instructed and supervised, to carry out the work safely.

[c] All work involving hazards has prior approval. The work should be necessary and safely planned. Provision should be made for preventive or emergency action, and prior medical advice should be sought where necessary.

Suitable provision is made for dealing with emergency situations of all kinds and that there are adequate first aid facilities in the Department. The Heads of Department and staff in charge of laboratories must keep their Safety Officers informed on matters of safety and have approval before starting hazardous work.

Organization of Safety Responsibilities

Governing Body (Employer)

President

Departmental Heads
Members of Staff
Students, Others

2.3 Work involving a serious hazard

Work of this nature should be carried out to a specific routine, approved by the Head of Department and Safety Officer. Staff should be offered protective vaccinations and blood tests where appropriate. These measures are for the protection of staff.

2.4 Responsibility for work

All workers in the laboratory must take responsibility for safely conducting their work. They should ensure that:

[a] They have approval from their Head of Department, Supervisor and/or Safety Officer.

[b] Both they, and their helpers, understand the hazards and the protective measures to be taken and have considered whether any consequential hazards to staff in their own or other sections may arise, and that safety facilities are available and emergency procedures effective.

[c] The work is properly planned, the written instructions for the work incorporate safe practices and that the procedures are understood and agreed by all staff involved and/or likely to be involved in the work.

[d] Hazardous procedures are carefully controlled throughout, and not left unattended unless it is clearly safe to do so. On completion of the work everything should be safely stored, disposed of, or rendered harmless as soon as possible.

[e] The Safety of any person who may enter the laboratory at any time is safeguarded. This includes non-laboratory staff whether or not directly employed by the laboratory. Prominent warning notices should be placed on doors (including doors of rooms where dangerous work is done) and close to possible hazards.

2.5 Individual responsibility

Every person, whatever grade, has a duty to protect both himself and others from any hazard arising from his/her work. To make sure of this he/she should observe the following rules:

[a] He/she should carry out hazardous work only when he/she has the approval of his/her Safety Officer.

[b] He/she should read and follow the safety code carefully.

[c] He/she should understand clearly his/her part in any hazardous procedure, and be sure he/she can carry it out safely. He/she should understand the hazards and the precautions to be taken. If he/she is in any doubt on

matters of safety, he/she must consult his/her Safety Officer until all his/her doubts are resolved.

[d] He/she should follow the written instructions for all work involving the possibility of hazard.

[e] All such work must be carefully planned and prepared, with regard to the safety of others. He/she must remain in full control of his/her work, and afterwards make everything safe as soon as possible.

2.6 Sickness and Injury

First aid for sickness and injury occurring in working hours should be available from trained first aiders and every laboratory should have its own poster of emergency procedures and telephone numbers which includes first aiders. Wall mounted first aid boxes are positioned at convenient points in all laboratories (with two in the undergraduate laboratory). All injuries received during work, no matter how trivial they may seem should be reported on the official "Accident report form" (available from Executive Assistant). The completed report must be signed by the individual's supervisor/staff member in charge at the time of the accident and submitted to the College Safety Committee via the Departmental Safety Officer.

Incidents not involving injury, but which could have caused an injury or have given rise to a serious hazard, must also be reported on the official "Incident report form". The procedure is as for accident reporting. Any such incident in a biohazard or radioactivity handling area must be reported immediately to the Safety Officer.

2.7 Emergency procedures

Emergency procedures are laid down for fire and explosive hazards (see 5.0) and infective hazards (see 8.1) and for accidents involving injuries to eyes (see 3.3). The emergency notice in every laboratory lists the telephone numbers to ring during and outside normal working hours. Work of a hazardous nature undertaken outside normal working hours must be authorized by the Head of Department in consultation with the Safety Officer.

3.0 Protective Clothing

3.1 Choice of clothing

Protective clothing must always be worn in the laboratory .The Supervisor in charge of the work, or the Safety Officer, must specify the types of clothing to be worn for the work in hand.

Protective clothing (including the standard laboratory coat) must be kept separate from personal clothing, which should preferably be kept in a locker outside the laboratory environment. Laboratory coats should be hung on a peg in the laboratory before visiting clean areas e.g. restaurant, library, tea room, Administration Offices, etc.

Protective gloves should be removed once the procedure requiring their use is completed. Unnecessary touching of body surfaces (e.g., face or hair) is to be avoided while wearing protective gloves. Protective gloves should **NEVER** be worn into clean room areas.

3.2 Decontamination of clothing

It is the duty of Supervisors to ensure that clothing which has become contaminated is at least sufficiently decontaminated to make it safe for handling by domestic and laundry staff. Measures should be adopted to meet local conditions for handling of laundry. Heavily soiled or blood-stained materials for laundering must have a preliminary cleaning before leaving the laboratory.

3.3 Protection of eyes

A common laboratory accident is a splash when pouring corrosive liquid. This is very serious if the eye is involved; a face shield, and if necessary other protective clothing, should be kept handy and used where these liquids are handled. Acids and alkalis are most commonly involved.

A means of safely washing out the eyes must be immediately to hand whenever corrosive, toxic or infective materials are handled. This can be a tap fitted with rubber tubing or an approved eyewash apparatus. The important thing is to wash the eyes immediately and continuously for several minutes. If contact lenses are worn, they should be removed as quickly as possible so that the eyes can be washed thoroughly. Eyewash bottles are provided (in first-aid cabinets), and are kept under the direct control of a named staff member who is held responsible for keeping them in good condition.

In all cases where the incident has involved the eyes, after appropriate emergency measures have been taken, the victim should be brought to hospital to check that no damage to the eyes has occurred.

4.0 Parcels Containing Biological Materials

If required please consult the Main Departmental Safety Manual

5.0 Fire Hazards

Official Fire Notices are displayed in the building providing instructions in case of fire, and information about facilities available in an emergency.

5.1 Fire prevention

The Fire evacuation drill procedure is included at the end of this section of the Manual. Familiarise yourself with the instructions it provides and STRICTLY ABIDE BY IT when the Fire alarm sounds. Remember that visitors and new staff may not know the layout of the building and may get confused in an emergency. Exits should be clearly marked and never be obstructed. Senior staff should know where gas, electricity and water supplies could be turned off in the building. Keep fire doors closed and keep flammables away from naked flames (e.g., ethanol/bunsen burners).

In the event of a major fire the first objective is to get everybody out of the affected area by sounding the fire alarm. On hearing the alarm, staff should leave the building and assemble at the assembly point as instructed by the fire marshal. A minor fire (such as a fire in a waste paper bin) should be attacked with the nearest suitable appliance or by turning off the fire source, e.g. if fire is of gas or electrical origin. If possible, send for aid immediately and alert security requesting (if necessary) that gas, water or electricity supplies be switched off at central source.

Classes of fires and appropriate extinguishing agents:

A. (Paper, wood, textiles, etc.)	Use water, foam
B. (Oils, paints, solvents etc.)	Use foam, dry chemical vaporising liquids.

C. (Electrical equipment)	Use CO_2, dry chemical, vaporising liquids.
D. (Reactive metals -Na, Mg)	Use sand, salt soda, graphite.

Water and foam should not be directed at live electrical outlets or apparatus.

5.2 Evacuation

5.2.1 On hearing an alarm

(a) Teaching staff/Fire Marshals will:

(i) oversee evacuation of the Lecture Room, Laboratory etc., close the door, and

(ii) lead their class to the designated assembly point.

(b) Students will:

(i) if in class, follow the instructions of the person in charge, or

(ii) if not in class, form single file and go to the assembly point by the most direct route.

(c) All persons must be instructed as follows:

Not to take personal belongings
Not to run
Not to laugh, talk or make noise
Not to attempt to pass others
Not to return to the building for any possessions

(d) If feasible, designated staff should carry out a search of the building when evacuation is complete.

5.2.2 Assembly Points

The assembly points for individuals in the Biochemistry Department, at the time of the alarm sounding is either outside the front door of the Lee Maltings or the BSI. Other assembly points will be giving by individual project supervisors.

5.5.3 General

I. After initial practices to establish the procedure, practice drills should be held at least once per year. In particularly vulnerable areas more frequent drills are advisable.
II. Two and a half minutes from warning to complete evacuation should be aimed for.
III. An alternative method of familiarising staff with escape routes is to instruct them occasionally to leave the building by the alternative route at the end of a working day.
IV. If the fire cannot be extinguished in a matter of seconds, or in any event after the full discharge of the extinguisher, the major fire procedure must be follows:

SOUND THE ALARM CALL THE SECURITY OFFICERS

5.3 Fire Drills

In devising fire drills those responsible should be guided by the following points.

5.3.1 Raising the Alarm

- The action which is appropriate on discovering a fire will depend on how far it has developed, and how quickly it may spread. Many fires discovered in their early stages can be controlled by prompt action (i.e., use of fire blanket, extinguishers or turning off fire source e.g., gas mains supply).

- The person discovering a fire should:

  (a) SHOUT FIRE to alert persons near-by and to summon aid.
  (b) MAKE ONE QUICK EFFORT TO PUT IT OUT and then whether successful or not.
  (c) ALERT designated persons, i.e., supervisor or security personnel on the desk at extension 4100/4311 or 4145.

- The designated person should:

(a) if necessary, inform the Fire Brigade or Security as appropriate, and

(b) order the calling of the alarm and evacuation of the building if necessary.

5.4 Emergency procedures in the event of fire

These will be operated in accordance with the drill laid down for the building.

5.5 Other Points

5.5.1. Flammable reagents

Keep bulk quantities (> 5 litres) of flammable reagents outside in safety bins or purpose built stores. Have in the laboratory only enough for immediate needs. All must be labelled FLAMMABLE.

5.5.2. Vacating buildings

Before leaving laboratories and other work places vacant for long periods, particularly at night, ensure that everything is left safe. Doors and windows should be closed, and bunsen burners and other apparatus switched off at the gas tap. Fire and smoke doors must be closed.

5.5.3. Refrigerators

Refrigerators need to lose heat from their cooling grids. They may overheat if this is prevented in any way. Do not put anything on top of, or behind, refrigerators if this obstructs the passage of air around the cooling grids. Do not store flammable solvents in ordinary refrigerators, deep freezes, cold rooms etc. Specially constructed refrigerators, deep-freezes etc. are available which are spark-proof. Only these designated refrigerators etc. must be used for flamIf1able solvent storage.

5.5.4. Waste paper baskets

Waste paper baskets may be a source of fire, do not use them as ashtrays. It is recommended to use spark igniters and not matches for bunsens. The use of bunsens should be avoided wherever possible, e.g. by use of heating blocks instead of bunsen-heated water baths. Do not allow combustible material to accumulate in the laboratory;

get rid of it or put it away safely. Waste paper baskets must only be constructed from metal or other non-flammable material.

5.5.5. Sources of fires

Some situations which start fires in laboratories are: naked flames, hot plates, cigarettes, sparks from metal tools, electric sparks from switches and motors, static electricity, gas leaks, chemical reactions, pilot lights and 'burning glass' effect of flasks of liquid in sunlight. Smoking is not allowed in the laboratory or in any area where a fire hazard exists.

5.5.6 Hair

Long loose hair and large beards can easily catch fire from a bunsen flame. Flowing hair must be restrained.

5.5.7 Town or L.P.G. Gas appliances

One of the commonest potential sources of fire is the boiling dry of kettles, flasks and beakers etc. in unattended rooms. If you have to leave the room, turn off the gas supply, this is particularly important overnight. Do not leave pilot lights on. Check bunsen tubing regularly. Air or oxygen getting into gas pipes may lead to an explosion. No equipment using compressed air or oxygen should be connected to the gas supply unless a non-return valve is fitted. It is illegal to use any gas appliance or installation, which is faulty or unsafe. If there is a continuing leak of gas from any piece of equipment the supply must be shut off and the services engineer informed.

5.6 Classification of fires

5.6.1 General

It has been the practice to group fires, and their method of extinction into four Classes A, B, C, and D.

As a preliminary to assessing the effectiveness of various extinguishers internationally, agreement has been reached on the new classification of fires given in BS-EN 2. (British Standards Institution).

Extinguishing agents are dealt with only partly under each classification; detailed recommendations are made under 5.7.

5.6.2 Class A

Fires involving solid materials, usually of an organic nature, in which combustion normally takes place with the formation of glowing embers, are Class A fires.

The most effective extinguishing agent for most of these fires is water in the form of a jet or spray, but water should not be used on fires involving electrical equipment unless discharged from specially designed fixed fire protection equipment. In other cases, the extinguishing medium needs to be electrically non-conductive and will include carbon dioxide and vaporising liquids.

5.6.3 Class B

Fires involving liquids or liquefiable solids are Class B fires.

For the purpose of choosing effective extinguishing agents, flammable liquids or liquefiable solids may be divided into two groups according to whether they are miscible with water or not. Depending upon the group, the extinguishing agents will include water spray, foam (chemical and mechanical), dry powder, carbon dioxide and vaporising liquids.

It should be noted that there are other fires not within BS-EN 2 Class B on which water should not be used because of chemical reaction with the materials involved or in the vicinity.

5.6.4 Class C

Fires involving gases are Class C fires.

The most effective method of extinguishing fires involving gases is to cut off the supply. Water spray, dry powder, vaporising liquids and carbon dioxide are effective media for controlling or extinguishing the fire.

Gases may be either lighter or heavier than air; with the latter it may be safer to let the gas burn under controlled conditions until the supply is cut off.

5.6.5 Class D

Fires involving burning metals such as magnesium, aluminium, sodium, potassium, calcium and zirconium are Class D fires.

Normal extinguishing agents would be ineffective and even dangerous to use. Special materials and techniques are necessary.

5.7 Extinguishing Agents

5.7.1 Water

Water is the most widely available and effective extinguishing agent for most fires. Its value lies in its high thermal capacity and latent heat of vaporisation, ensuring maximum cooling of the fire. These same properties made it invaluable for the protection (applied either manually or by means of a fixed installation) of buildings, plant and storage vessels when they are exposed to heat radiation from a fire.

5.7.1.2 Method of application and equipment

1. Jet -Water in jet form using fire main or pump pressure is used when a fire situation has progressed to the stage that long reach is required or alternatively maximum penetration into narrow spaces is desirable. Jets should not be used where there is the danger of dispersing burning material over a wider area. Because of the considerable reaction thrust from a large jet, an unaided and inexperienced person should not be expected to handle such equipment.

2. Spray - For the purpose of this Code, water spray may be regarded as coarse or fine. Coarse spray is used for most general applications, for cooling and for liquid fuel fires. Such a spray may be given by a hand-controlled branch used with a hose line, or by sprinklers or other spray devices in fixed installations. A coarse spray is more resistant than a fine spray to deviation by winds, but it should be noted that high density forceful discharge might cause 'splash' fires when directed on to burning liquids. Fine spray is suitable for manual application to small surface fires. Irrespective of whether a coarse or fine spray is required and subject to the design of a particular nozzle, water pressure between 5.5 bar and

8.3 bar (80 Ibf/in2 and 120 Ibf/in2) are normally required for effective hose-line sprays. Pressures over 10.4 bar (150 Ibf/in2) are used for producing water fog.

5.7.2 Foam

Fire-fighting foam is an aggregate of gas filled bubbles formed from aqueous solutions. Foam forms a heat-resistant coherent blanket, of density less than that of any flammable liquid and is thus able to extinguish fire by cooling and by preventing access of oxygen to it.

5.7.2.1 Types of foam

1. The following are two principle types of foam in use:

- Chemical foam. Produced by the reaction of alkaline and acid solutions in the presence of a foam stabilising agent. The carbon dioxide pressure generated by the reaction is utilised to expel the foam. Mostly restricted to portable extinguishers.

- Mechanical or air foam. Formed by the turbulent mixing of air with a pressurised water supply into which a small percentage of a foam forming agent has been introduced.

2. Another type of form is alcohol resistant form. Special materials and techniques are required when dealing with water-miscible solvents by means of foam. The normal grades of foam compound are unsuitable unless in certain instances, an extremely high application rate is achieved. Such solvents absorb the water from the foam bubbles, causing the complete breakdown of the foam and not much help will be obtained unless the application rate far exceeds the breakdown rate. There are alcohol resistant foam compounds that are better than the standard grades for this class of fire, but application techniques are most important. A fixed installation should be considered. The alcohol resistant foam compounds can be very corrosive and, therefore, particular attention needs to be paid to the vessel in which they are stored. Plastics lining or plastics treatment of containers is advised. Whilst some of the alcohol resistant foams can be used on hydrocarbon

fires, the resultant foam is not nearly as effective as that produced by the normal foam compounds and should not be considered fully dual purpose.

5.7.3 Chemical Agents

Certain liquids (halogen compounds), which vaporise in air have the property of extinguishing fire. This is achieved in two ways:

1. by diluting the atmosphere in the immediate vicinity of the burning material to a point where the oxygen present is no longer capable of maintaining combustion.
2. by interfering with the chemical reaction of flame propagation in the burning material.

The proportion of extinguishing medium which is required to achieve the combined effect of (1) and (2) is particular to that medium and is usually referred to as the "inhibitory factor". It is expressed as a percentage in dry air.

A laboratory method of comparing the fire extinguishing efficacy of vaporising liquids is by the measurement of the 'peak flammability value', i.e. the minimum concentration of the medium needed to prevent ignition at all concentrations of a flammable vapour in air.

These vaporising liquids are toxic in varying degrees and toxic decomposition products can be formed in a fire. Care should be taken when using these media in areas of poor ventilation. In the light of research carried out by the Fire Research Station, Joint Fire Research Organisation, United Kingdom Department of the Environment, on the toxic properties of the various vaporising liquids, it has been concluded and agreed that carbon tetrachloride (CTC) methyl bromide (MB) and 1,1,I-tricWoreetthane should no longer be used in hand fire extinguishers. Other commonly used vaporising liquids, namely chlorobromomethane (CB), bromocWorodifluoromethane (BCF) and bromotriflluoromethane (BTM), are acceptable.

Vaporising liquids are very suitable for small fires involving some types of flammable liquid, and by reason of being electrically non-conductive, for fires in live electrical equipment. They do not, however, provide permanent sealing of the fuel as in the case of foam. Re-ignition is therefore a hazard, which should be countered by the provision of adequate extinguishers, training and usage. Extinguishers are generally of the portable

type pressurised by nitrogen. Certain unattended risks may be suitably protected by automatic fixed fire-extinguishing installations using vaporising liquids.

5.7.4 Dry powder

Various chemicals in powder form are used in a wide range of pressure-operated fire extinguishers. These can be either of the cartridge-operated type or of the stored-pressure type. The fire-fighting action of almost all dry powders depends on interruption of the chemical reaction of combustion. Dry powders in general are extremely effective in flame knockdown, the powder acting while in the form of an airborne cloud of particles.

5.5.4.1 Types

The most important types of dry powder currently in use are as follows:

1. Bicarbonate based powder. The sodium bicarbonate based powder is the most widely used and it is important for its Class B fire-fighting performance. Higher efficiency has been claimed for powders based on potassium compounds.

2. General purpose dry powder. Various mixtures of chemicals are used for general purpose dry powders, but most powders contain ammonium phosphate. The powder has good Class B fire- fighting properties, but also has the advantage of Class A performance. Extinction of the Class A fire is usually achieved by the property the powder has of fusing in contact with hot material and thus forming a fire-inhibiting layer, which prevents smouldering, and re-ignition.

3. Foam-compatible powder. Most dry powders are incompatible with mechanical or air foam, as the chemicals used tend to break down the bubble structure. However, certain powders have been developed which are, to a high degree, compatible with foam. A good example of such powder is that based on potassium sulphate. This applies particularly to the site where the large types of dry chemical equipment are located and where it is probable that additional fire fighting will be undertaken by means of large quantities of mechanical foam.

6.0 Mechanical & Physical Hazards

These hazards, resulting mainly in cuts, abrasions, bruises, fractures and similar injuries, are the commonest sources of accidents, all of which must be recorded on an Accident Report Form and handed to the Departmental Safety Officer.

6.1 Cuts from glass

Glass is the major hazard in this group. Be meticulous about clearing up broken glass, especially from benches, sinks and plug holes. Fixing or removing glass tubing from rubber tubing or bungs can be dangerous. When removing, cut away the rubber using several layers of cloth to hold the glass tubing. Whenever possible use the special holders, which have been designed to do this job safely. Ready bored bungs fitted with plastic tube inserts to which tubing can be connected are available for many standard fittings, use these whenever possible.

Special treatment may be needed quickly for cuts from infected glassware or knives. Whilst limiting the free bleeding, consult a qualified/competent person urgently for the recommended disinfection procedure for the cuts before going further with the first aid. Particular care is needed in emptying bins in which glass ware has been autoclaved; they often contain glass broken by the process.

6.2 Other cuts

Scalpels, post mortem knives, microtome knives and other sharp edged instruments must be carefully handled. Carry them well protected. Never leave microtome knives unguarded and carry them only in the proper container. Remember trivial cuts may be very dangerous when working with pathogens. Take great care when trimming tissue specimen block for sectioning. Work involving the use of microtome knives must not be attempted in cramped conditions, and must be free of sudden distractions.

6.3 Burns and scalds

Burns arise from solvent fires and explosions (see 10.7), Bunsen burners, autoclaves, tripods, ovens, hot plates, wax, microbiological media and glass tubing. They also commonly occur during the operation of incinerators. Staff opening an incinerator door must always wear insulated gloves and heat-proof visors.

Scalds commonly occur as a result of heating large vessels of liquid on boiling rings on a bench surface. This often occurs in washing up rooms and reagents or microbiological

media preparation areas. When large volumes of liquid must be heated by gas this should be done in strong vessels constructed of stainless steel or similarly strong material rather than glass. The vessel must rest firmly on a gas ring placed on a shallow tray mounted preferably at a level lower than that of the laboratory bench.

6.4 Falls

Serious injury can result from slipping on wet or greasy floors, tripping over objects left lying about, and when carrying heavy or awkward loads. Keep floors dry, clean and free from clutter and make use of trolleys. All corridors, walk-ways, escape routes; hallways, passages etc. must be kept free of debris, clutter and hazardous materials.

6.5 Machinery

Moving parts of machines must be properly guarded; loose flowing hair should be controlled when working with machines.

6.6 Vacuum apparatus

Anaerobic jars, desiccates, filter flasks and other glass pressure vessels must be of vacuum grade and should be carefully inspected for cracks, scratches and flaws before use. When very high or very low pressures are used, the glassware should be enclosed by a purpose made wire cage. This can conveniently be made from aluminium expanded-metal sheet of suitable gauge and mesh size. For pressures used for the filtration of culture media and chemical deposits, simple precautions such as the use of transparent polycarbonate screens (not perspex which splinters in explosions) or simply taping the vessel with either P .V. C. electrical insulation tape or paper masking tape. Face visors should also be employed. If the substance being processed could be harmful then the appropriate protective clothing, including face mask and visor should be worn. When in doubt consult a senior staff member.

6.7 Liquefied gases and solid carbon dioxide

These substances should be kept in well-ventilated rooms and used with great care. The most commonly used liquefied gas is nitrogen and this can asphyxiate if a large quantity is spilt inside a small room or vehicle. Clothing should be selected to give full protection against spills and the boiling liquid. When transporting liquid nitrogen, the containers must be firmly secured in a compartment (such as the boot of a car), which is separated from the driver, and not carried inside the vehicle. A particular hazard is presented by the

withdrawal of any sealed container (glass, plastic or metal) that has previously been immersed in the liquefied gas. If there is a flaw in the container, the liquefied gas will have entered the container and will boil when the container is exposed to ambient temperatures, resulting in an explosion. A face visor must therefore be worn and other appropriate precautions taken, e.g. ampoules removed by tongs and hands protected by heavy gloves and strong shoes (not sandals or open-top shoes) worn. It is better to store materials in the vapour phase whenever possible.

Solid carbon dioxide (dry ice) should be handled with insulated gloves, breaking and crushing should be done with the lumps inside a thick cloth and whilst wearing a face visor. This should be done in a well-ventilated area as carbon dioxide can asphyxiate.

6.8 Ultra violet light

Care must be taken to protect eyes (by wearing appropriate glasses or goggles) and skin, (by wearing a face visor, gloves and a lab coat) from ultra-violet light. Ultra violet light is commonly used in the laboratory in gel illuminators, in microscopy, chromatography, mutagenesis and air or liquid sterilization processes. Direct and reflected rays are damaging. Serious hazards causing blindness can lie in looking down an ultra-violet microscope in which the appropriate filters are not fitted or a nucleic acid gel transilluminator and in removing covers from lamps housing of spectrophotometers and fluorimeters. Some ultra-violet lamps may produce excessive ozone, these should be replaced. Ozone is a very toxic substance with a threshold limit value (TLV) of 9.1 pm. It is very irritating to the eyes, throat and lungs and long-term exposure may produce chronic liver changes. Dark rooms where U.V. lamps are used should be ventilated by an extractor fan.

6.9 Centrifuges

The potential hazards from centrifuges are very considerable. They may arise from mechanical faults or from infection risks from the loads (see 8.1). The best defence against mechanical failure of any part of a centrifuge is to purchase a model which conforms to the British Standard; to keep it clear (regularly inspected for signs for corrosion in the bowl, drive shaft and rotors) and properly serviced. Recommended procedures for balancing loads and operating the centrifuge must be followed for each particular model. Points to observe when loading and running a centrifuge include: use correctly matched buckets and trunnions; avoid the use of glass tubes when possible, and never use scratched or damaged tubes; balance loads carefully using containers of the same type as the load container and fluids of similar specific gravity as the load; never

balance by pipetting fluids directly into buckets; in the case of swing out rotors make sure the trunnions are correctly positioned, and fill all the places even if not all are required for the load; make sure the lid is f1m1ly secured before starting up, and do not leave the centrifuge before the required speed is reached; if the load has a specific gravity greater than 1.0, reduce the maximum load by the factor indicated in the manufacturer's instruction book; do not attempt to open the lid until the rotor has stopped rotating, and always return the speed control to zero position after a run. Be prepared to deal with breakages that are found when the run is complete and to deal with apparent breakages or mechanical failure during a run. This may mean evacuating the room as soon as the power has been switched off - it is obviously desirable to trip a circuit breaker outside the room door. A book should be kept recording the period and conditions of use. A maintenance record should be kept for each centrifuge.

Special conditions apply to the use of high-speed centrifuges (ultracentrifuges) and the relevant instructions should always be available near the centrifuge. Operation of ultracentrifuges will always involve limited access and careful logging of their use. Flammable liquids must not be centrifuged unless it is known that the centrifuge motor is spark proof. The solvent compatibility of plastic tubes and bottles must be known before filling.

6.10 Autoclaves

Most modem autoclaves are safe to use if the appropriate instructions for their use are closely followed. In older models it is possible for residual steam or boiling water to be present in the chamber when the gauge shows no pressure, so the door should always be opened cautiously. In addition, fluids may boil explosively after autoclaving, so a sufficient period of time should be allowed to elapse before opening the door.

Bench-top autoclaves need considerably more care taken in the operation because of the lack of automatic safety devices.

7.0 Electrical Hazards

7.1 Electricity

Electricity, as a source of energy and because of its flexibility, is to be found in many forms throughout the laboratory.

7.2 Precautions

Because you can neither **SEE**, **HEAR** nor **SMELL** electricity, special precautions must be taken in its use, if severe shock or electrocution is to be avoided. Attention should be paid to the "General Factories Acts Notices" (obtainable from Dept. of Labour) dealing with situations of electric shock and the methods of coping with it. These notices should be displayed in prominent positions and brought to the attention of persons using the Department laboratory or unit. If it is necessary to determine whether a particular circuit is live, then an appropriate phase tester or meter should be used.

7.3 Inspection

Regular inspection procedures should be carried out to maintain electrical equipment in a safe and serviceable condition by competent service personnel.

7.4 Dangerous environments for electricity

Special precautions are necessary, when using electrical equipment in the following environment conditions:

A Dry Locations
B Damp Locations
C Outdoor Locations
D Wet Locations
E Underwater Locations
F Corrosive Locations
G Extreme Temperature Conditions
H Flammable Conditions
I Explosive Atmospheres

7.5 Electrical Fires

Certain fire fighting precautions are necessary when dealing with electrical fires (see under fire fighting in section 5.1).

7.6 Codes and Regulations

National Codes and regulations ("Electrical Equipment of Buildings" and "The National Rules for Electrical Installations") are available.

7.7 Advice on electrical appliances etc.

Those responsible for laboratories and workshops should consult a senior staff member about the suitability of particular electrical appliances for the areas in which they are (or are to be) located. Specialist advice should be sought for any special circumstances, which might render electrical appliances dangerous e.g., wet, or gaseous environments.

7.8 Treatment of electric shock

Switch off electricity supply and remove person from the appliance. Call for assistance immediately (a doctor/an ambulance) and have someone stay with the person to comfort and aid until medical support arrives.

7.9 High Voltage Equipment

High voltage supplies are those having a potential greater than 650 volts. Persons working with high voltage equipment should be familiar with the apparatus. This is especially important for service technicians who use high voltage test equipment. Trainees and inexperienced personnel should be instructed as to the dangers (if any) and the precautions to be observed while working with high voltage equipment. Trainees and inexperienced personnel should be under adequate supervision by a person who has experience and knowledge of the apparatus. Maintenance of equipment should be carried out in an area free from exposed earths, with insulated floor covering and worktops.

Leads and connections to equipment should be inspected regularly so should all safety and interlock cutouts.

Notices warning of the presence of "High Tension" must be displayed and it should be noted that high voltages might still exist in equipment even after the electrical supply has been switched off.
Charged capacitors can deliver a shock even when the power supply is isolated, therefore, the terminals should be shorted before attempting to service them. Because capacitors can recover charge, their terminals should be shorted while in storage.

7.10 Static Electricity

If required please consult main departmental safety manual

8.0 Microbiological Hazards

Before working with any micro-organism, it is necessary to know its degree of pathogenicity and to follow the recommended procedure for handling it. Consult the Safety Officer in the Department before bringing pathogens into the Department.

8.1 Sources of infection

8.1.1 Contact

Micro-organisms may penetrate the mucus membranes of eye, nose or mouth. Many micro-organisms can also get into the body through cuts or scratches, however trivial. Benches, equipment, clothing and other surfaces may remain contaminated for several days or longer - even for years in the case of spores.

It is therefore necessary to cover cuts and scratches with a waterproof dressing before handling micro-organisms. Also, swab down benches and work areas with a suitable disinfectant before leaving and wear a buttoned laboratory coat at all times. This laboratory coat should not be worn outside the laboratory. Wash your hands thoroughly with disinfectant before leaving the work area.

8.1.2 Airborne Contamination

Splashing of liquids (aerosol generation) can cause contamination of the skin, clothing and working areas. Inhalation and infection via the eye are common routes of laboratory infection as many organisms become airborne easily during handling. For aerosols generated during work with pathogens of categories A or B it is necessary to use a safety cabinet. For work with less hazardous micro-organisms it may be necessary to wear a safety mask. Many common procedures produce invisible minute droplets of invective fluid (aerosols), which become airborne and may be inhaled.

Aerosols can be produced by any operation involving splashing or turbulence such as pipetting (especially if the fluid is forced out), shaking, centrifuging, siphoning, opening ampoules, releasing gas pressure from a culture tube and even the opening of screw capped containers such as universal containers. The risks of leakage from chipped screw capped containers, particularly when they are shaken, is very great and includes the formation of aerosols.

Dry or dust forms of organisms (such as sporing moulds and freeze-dried preparations) easily become airborne. Care should be taken to keep the dust down, by damping if possible.

8.1.3 Ingestion

This may occur from pipetting accidents. Any mouth operation is dangerous when working with micro-organisms; mouth pipetting of pathogens is therefore prohibited. Ingestion may also results from contaminated cups, cigarettes, fingers, pipettes and leaking closures on bottles (See 8.1.2).

8.2 Hygiene

8.2.1 Personal hygiene

A high standard of personal hygiene can clearly cut down the infection hazard. Always wash your hands after working with pathogens, with a suitable disinfectant and before leaving the laboratory.

8.2.2 Health

Injuries and ailments, however trivial, may increase the hazard. Pay special attention to cuts, scratches, boils, chapped hands, and other skin troubles. These and any illness should be reported to your Safety Officer and Supervisor.

8.2.3 Laboratory cleanliness

Keep the laboratory scrupulously clean, tidy and dust free and correctly ventilated.

8.2.4 Eating, drinking and smoking

There must be no eating, drinking or smoking in any laboratory, or other places where biological, radioactive or toxic materials are handled.

8.2.5 Vermin

Rats, mice, insects and other pests in buildings should be reported to the Safety Officer.

8.2.6 Vehicles

Care is necessary whenever biological material is carried in cars. Protective clothing must be removed before getting into the car, and the car boot cleaned after use. Biological material should be carried in a strong, leak proof container and any spills cleaned carefully and made safe.

8.3 Treatment of invective material

8.3.1 Disinfection

A supply of an appropriate approved disinfectant must be kept ready for use whenever pathogenic material is handled. The recommended methods for use must be observed.

Disinfectant must always be made up to the correct dilution for the job and handled with care and the appropriate protective clothing must be worn. For most applications of disinfectants there is an approved laboratory procedure; where this is not available advice should be sought from the Departmental Safety Officer.

8.3.2 Sodium hypochlorite

Sodium hypochlorite solutions e.g. industrial grade Chloros (ICI) are often used as disinfectant; they depend on the presence of free chlorine for their activity. These solutions are very alkaline and corrosive particularly to metals; organic materials, metals and the action of bright sunlight greatly reduce the activity of hypochlorites and render them ineffective. Fresh solutions should therefore, be made up daily and the undiluted product stored in a cool dark place. The persistence of the pink colour (permanganate) in a Chloros solution indicates only that there is some free chlorine present. It does not necessarily mean that there is enough for effective disinfection to take place. Containers of strong hypochlorite solution must be vented or they may explode because of a build up of chlorine.

Lysol is a cresolic disinfectant and its discharge into drains must be kept to a minimum because cresols destroy the bacteria in the digestion plant at the sewage works. It can, however, still be used in some specific biohazard areas such as for work with *Mycobacterium* and *Brucella Spp*. At 3 per cent Lysol will, given sufficient time, kill vegetative bacteria including *Mycobacterium Spp*. but is not effective against some spores and viruses. Hypochlorites and cresolic disinfectants should not be mixed as this inactivates both.

8.3.3 Formaldehyde and glutaraldehyde

Formaldehyde and glutaraldehyde are effective against most vegetative and sporulating bacteria, fungi and viruses. Formalin HP solutions contain about 40 per cent formaldehyde (w/w) in water. The usual 2 per cent solution of formaldehyde is obtained by making a one in twenty solution of formalin in water.

Formaldehyde, paraformaldehyde and glutaraldehyde can all be used as fumigants for rooms and cabinets. For fumigation to be effective the temperature must be above 15°C, the room properly sealed, the atmosphere humid and the volumes of gas and time of exposure adequate. If the aldehyde gas is smelt during or after a fumigation there is sufficient toxic vapour to be an inhalation hazard. If rooms cannot be properly sealed during fumigation or properly ventilated after fumigation, this method of decontamination should not be used. The precise method of fumigation will vary with each situation and should be clearly laid down in the form of written instructions to be agreed with operating staff. After fumigation, a room must not be entered nor a cabinet opened, until the space has been well ventilated for a prescribed period of time. In exceptional circumstances, with the permission of a senior officer and with another person stationed outside the room, the operator can safely enter a fumigated room after it has been well ventilated but before the end of the prescribed period provided approved breathing apparatus is worn by both persons (see 10.0).

8.3.4 Ultra-violet rays

Ultra-violet rays from bactericidal lamps, though of limited application, are of value under some circumstances for air and surface decontamination. Care must be taken to protect the eyes and skin from both direct and reflected rays. The lamps produce ozone and may be a hazard if the room is not well ventilated (see 6.8).

8.3.5 Disposal of Pathogens

After use, infected glassware (including microscope slides) and other materials, which will withstand autoclaving, should be put into discard boxes and autoclaved. If the box contains broken glass this should be clearly indicated on the box lid. An indicator tape or similar means should be used to show that the box has been through the sterilising process. Discarded pipettes should be disinfected before removal from the laboratory. If pipettes have been discarded into hypochlorite solution, this should be neutralised by the addition of sodium thiosulphate before autoclaving.

Acids and alkalis should not be allowed to run free in aluminium discard boxes. If large volumes of liquid are autoclaved, special care should be taken to ensure that they are adequately cooled before opening the autoclave and removing the contents, which may

boil explosively if removed too soon. Plastic disposable petri dishes and other plastic containers should be discarded into polythene bags. If these contain pathogens they should be sealed and autoclaved before disposal. Otherwise they should be put into the approved paper sacks, securely sealed and labelled on the outside "Used Petri Dishes" and placed in dustbins for disposal by incineration. Animal tissues and similar materials for destruction may also be put into paper sacks, but the sacks must then be put into metal dustbins. Dry bedding and dung from animal cages may be incinerated in paper sacks or sterilised by steaming or autoclaving before being discarded into lined paper sacks. Rodent and carrion attack must be prevented.

Hypodermic needles must not be discarded into bags or sacks, but either placed inside the rigid boxes or rendered safe by one of the special systems available for the discarding of such needles.

Bottles to be discarded or returned to stores must be thoroughly washed out, if being sent for disposal they should have their stoppers removed. See Section 10.5 for the disposal of chemicals and their containers.

8.4 Microbiological safety in laboratories

8.4.1 Pipetting

Never pipette by mouth, a range of approved pipetting devices to meet all needs is available. Do not blow out pipette contents and do not bubble air through infects fluids.

8.4.2 Exhaust protective cabinets (Safety Cabinets)

These cabinets are used for the maximum protection of both the operator and the environment. A British Standard is available. Other types of cabinet in which both product and operator are protected may be introduced. For all types of cabinet and for each mode of operation a written laboratory safe procedure should be prepared in consultation with those who use the cabinets in Biohazard Areas.

8.4.3 Incubators and refrigerators

Shatterproof containers should ideally be used for storage, sealed to prevent contamination, and properly labelled with name and date. Food and drink must not be stored in refrigerators or cold rooms used for laboratory purposes. Invective materials

stored in refrigerators and deep freezers must be in leak-proof containers able to withstand low temperatures.

8.4.4 Centrifuges

The centrifuging of fluids always gives rise to aerosol formation, so that the centrifuging of dangerous invective fluids should always be done in sealed bottles in a sealed rotor of an approved type and these should always be opened in an exhaust protective cabinet (See 8.4.2.). Ordinary screw-capped and other containers almost invariably allow the escape of aerosols during centrifugation and should not be used for invective fluids in unsealed bucket rotors. (See also 6.9 for the mechanical hazards of centrifuging).

8.4.5 Freeze Drying

Consult main departmental safety statement

8.4.6 Opening of ampoules

Ampoules of freeze-dried pathogenic material should be opened in such a way that air can slowly enter. If air is allowed to rush into a partially evacuated container, the contents may be blown out as a dust. If the scratch line around the ampoule is touched with a red hot glass rod, a crack will run around the tube and air will enter slowly before the tube is fully opened. Ampoules containing category A and B pathogens must only be opened in exhaust protective cabinets.

8.4.7 Shakers, Blenders, Homogenisers and Grinders - Use with pathogenic material

Aerosols containing infected particles may escape from shakers and homogenisers between the cap and the vessel. A pressure builds up in the vessel during operation. Glass homogenisers may break, releasing infected material and wounding the operator.

a. Electrical shakers and homogenisers

1. Caps and cuts or bottles must be sound and free from flaws or distortion. Caps must be well-fitting and gaskets must be in good condition.

2. Machines must be covered when in use by a transparent plastic casing of strong construction. This must be disinfected after use. Where considered necessary these machines, under their plastic covers, must be operated in an exhaust protective cabinet.

3. After shaking or homogenisation of dangerous materials all containers must be opened in an exhaust protective cabinet.

b. Glass Tissue Grinders (Griffith's Tubes, Ten-Brock Grinders)

1. These must be held in a wad of absorbent material in a gloved hand when tissues are ground.

2. If used for work with dangerous materials they must be operated and opened in an exhaust protective cabinet.

8.4.8 Ultra-sonic apparatus - Use with pathogenic materials

Ultra-sonic treatment of infected materials in suspension produces very substantial aerosols. Great care must be taken to ensure effective sealing between probe and vessel and where considered necessary these should be operated in an exhaust protective cabinet. The probe should not be allowed to come in contact with any part of the body.

8.4.9 Transport of pathogenic materials

Always transport invective or suspect material in leak proof metal containers. Label the material properly and use trolleys for larger items. Report spillages at once and make them safe as soon as possible (See section 4 for transport outside the laboratory).

8.4.10 Repair of apparatus

All apparatus must be disinfected and made safe before being sent for repair or maintenance, returned to store, or transferred to another section.

8.4.11 The cleaning of rooms

Make sure rooms and their contents are safe after work with infective material and before maintenance staff move in or the room is used for other work.

8.4.12 Autoclaving

The air extracted from the contents of an autoclave chamber under high vacuum is potentially contaminated with material from the contents. If the contents include

infective or toxic materials the chamber should be free-steamed for a period of from l-30 minutes (the period depending on the load) if a vacuum is to be applied. Where a steam ejector is used the risks are diminished because the steam makes the exhaust system hot.

8.5 Accident procedure

In case of spills, splashes and other contamination incidents the action needed will vary according to the circumstances and organism. Some important points are:

8.5.1 Before

Follow the written plan for the hazardous work. For new work a written plan must be agreed with all those involved. If necessary post a notice outlining the action. Have at hand all the equipment materials and protective clothing needed. Seek the advice of a senior officer and the Safety Officer before starting new work of a hazardous nature.

8.5.2 During

If an experiment goes out of control the first concern is protection of persons. Remember infective material may have become airborne, and evacuation of persons may be urgent.

Prevent access and warn others. Tell a member of staff. Prevent spread of contamination. Disinfect as appropriate and avoid mopping until disinfection is complete.

8.5.3 After

Medical advice and treatment may be needed. Investigate the cause and modify procedures as needed. The incident should be reported to the Safety Officer.

8.5.4 Personal decontamination

In most cases the following is useful, but always seek further advice:

Skin: First wash well with cold water then swab with disinfectant, wash with surgical soap. Do not scrub. Treat minor wounds with 2 % Chloros, and rinse. Mouth: Rinse well with water. Do not swallow rinse water. Eyes: Bath well with warm water (See Section 3.3). Contaminated clothing: Remove at once and leave at the accident site in a bin. Have a shower.

8.5.5 Accident report

A full accident report must be prepared and agreed with the staff involved, this is to be submitted to the Safety Officer. The report should include any suggestions that can be made for the avoidance of a repetition of the accident.

8.6 Specialist procedures in biohazard areas

Work with micro-organisms or their toxins which are highly dangerous or have a restricted distribution require the use of a laboratory procedure which is much stricter than that used for routine work.

Consult project supervisor **AND** Departmental Safety Officer **BEFORE** initiating work on such pathogenic micro-organisms.

9. 0 Safety In Animal Use

9.1 The hazards

The safety precautions for laboratory work apply equally when working with animals.
For full details consult main departmental safety manual

10.0 Chemical Hazards

These hazards exist in all laboratories, not just in chemical laboratories; they arise since chemical substances may be flammable (10.7), explosive (10.7), corrosive (10.8), poisonous (10.9).

Safe use of chemicals depends on recognising the hazards, i.e. carcinogens, mutagens and neurotoxins, etc. associated with each chemical and knowing the correct control measures. The guidance in this section includes the more common and significant situations but cannot cover all contingencies.

Points to consider in the safe use of chemicals include transport (10.1) storage (10.2), labelling (10.3), handling (10.4), disposal (10.5), preventive and emergency procedures (10.6).

10.1 Transport

Chemicals must be transported in a manner that is safe and appropriate for each particular type of chemical. Always transport winchester quarts in suitable carriers and fuming acids in enclosed polythene carriers. Never carry them by their neck or tucked under

your arm. Prevent glass bottles from banging together when they are being transported in trolleys or baskets.

10.2 Storage

10.2.1 Flammables

The main storage of explosives and flammables must be outside the building in lockable bins or separate isolated buildings if kept in significant quantities. Inside the laboratory appropriately designed storage cabinets or cupboards must be used. For quantities see section 10.7.3.

10.2.2 Statutory control

There is no particular law in Ireland, which specifically regulates the position with respect to the prevention of chemical accidents. A number of statutes regulate some areas in relation to handling chemicals.

These are:

a. The Local Government (Planning and Development) Acts, 1963 and 1976.
b. The Fire Brigades Act, 1940.
c. The Public Health (Ireland) Act, 1878.
d. The Factories Act, 1955 (Factories (Chemicals) Regulations, 1972).
e. The Harbours Acts, 1946 and 1947.
f. The Nuclear Energy Act, 1971 (Nuclear Energy {Radioactivity) Order, 1977).
g. The Dangerous Substances Act, 19972 (Regulations, 1979).
h. The Air Navigation and Transport Act, 1946 (Order, 1973).
i. The Transport Act, 1969 (Section 60).
j. The Merchant Shipping (Safety Convention) Act, 1952: The Merchant Shipping Act (Dangerous Goods) Rules, 1967.

Many of these Acts are very much out of date and are being or will be replaced by new legislation which is likely to be based on or influenced by international regulations, especially directives under EC law.

10.2.3 Segregate

Incompatible chemicals should be kept apart either in separate rooms or in different areas. Flammables should be kept separate from oxidants and acids away from compounds from which they will release toxic gases (see reference 1 for reactive

chemical hazards). More dangerous compounds, particularly liquids should not be stored on high shelves or on the floor, or anywhere they can be kicked or knocked against each other.

10.2.4 Avoid heat

It is important that volatile compounds and flammable chemicals are not stored in warm places or in direct sunlight. Apart from many organic solvents this includes ammonia, peracetic acid, hydrogen peroxide, sodium hpochlorite and chromic acid solutions. Concentrated solutions may need venting from time to time.

10.2.5 Containers

Unused chemicals should not be returned to stock bottles as a mistake may lead to an accident. Always keep chemicals in sound containers, which are clearly and properly labelled and date stamped. Chemicals should not be stored indefinitely unless there is a foreseeable requirement for their use within the survival time for both the chemical and its container.

10.3 Labelling

Correct identification of all dangerous substances, so that the hazards can be recognised and dealt with, is a prerequisite of all safe handling systems. The essential information needed on each sub-stock solution of the reagent is:

Chemical name	Concentration	Diluent
Hazards	Precautions	Prepared by/for
Date		

Where several synonyms exist for a chemical the most well-known name should be used. Avoid using code numbers or trivial names, which give insufficient identification of contents and potential hazards.

Whether applied direct to the container or indirectly through a firmly attached label the name of the chemical must be unambiguous and remain legible throughout the entire usage of the container contents. If there is any doubt about the true identity of a chemical due to loss of label or illegibility then it must be discarded carefully (19.5).

When dispensing or transferring chemicals from one container to another all the relevant data must also be transferred.

Recommendations on labelling chemicals are made by the EC, and all the chemical reagent manufacturers must follow these directives. See reference 6.

10.4 Handling

If you are not sure about the safe handling of any chemical you intend to use, then consult information and reference sources (such as the Merck index), which is available in the Department or ask your supervisor.

10.5 Disposal

The only statute, which covers the disposal of waste, is the Local Government (Water Pollution) Act 1977, under which the Minister for the Environment or a local authority may issue licences to permit the discharge of trade or other waste into sewers. 'Trade' includes any scientific research or experiment. A Water Pollution Advisory Council exists to advise the Department of Environment. At present the College is not required to hold a licence under the Act for its discharge into the sewers. It is the responsibility of the Department of the Environment to see that proper and safe disposal facilities exist for all waste. Advice for making compounds safe for disposal is given in reference 3, 5 and 6.

10.5.1 Discharges down the sink

In general no material should be allowed down the sink, which will create a hazard to the environment or a nuisance in sewage processing. Significant quantities of dangerous substances, which cannot first be rendered harmless, must not be discharged this way. Detailed guidance on how to make compounds safe for disposal are given in references 3 and 6.

The type, amount, temperature and pH of effluent to the sewage works are subject to agreed restrictions and are periodically monitored. Laboratory safety notices give instructions and guidance on disposal and are designed to ensure that these agreed limits are not exceeded. Innocuous compounds and small quantities of all but the highly toxic compounds may be disposed of via the laboratory sink, in both cases the guiding principle is to flush them away with copious quantities of water.

Substances that react violently with water or flammable chemicals, or solvents immiscible with water or very foul smelling compounds should be kept in separate

containers and not disposed of in this way. Waste chemicals awaiting disposal must be kept in a properly designed waste store.

10.5.2 Depositing on the Ground

Restrictions on dumping solid or liquid waste are designed to protect wildlife in rivers and streams and to avoid contamination of drinking water sources.

The most dangerous substances, which include highly toxic, reactive, explosive or unlabelled compounds, must be disposed of via a licensed waste disposal contractor provided they are safe to transport. They must be collected separately and held in a waste store pending disposal.

The less dangerous ones, for instance flammable solvents, substances with low water solubility and all compounds degradable by soil bacteria, can be disposed of in a safety pit or by controlled burning in a specially designed and operated burner.

Approval must be obtained for dumping on the ground by any route.

10.5.3 Discharges to atmosphere

All staff have a statutory responsibility not to discharge any agent to the atmosphere that could damage the environment or cause hurt or harm to individuals or property on or off the premises.

Atmospheric contaminants may arise as dust, fumes or vapour and originate in such things as solvent evaporation, the incineration of waste, or from the unscrubbed exhaust outlets of fume cupboards and safety cabinets.

Provided they disperse readily, small quantities of many airborne agents such as flammables, corrosives, toxic lachrymatory or foul smelling compounds can be discharged this way.

10.5.4 Dustbin

Disposal of all chemicals via the dustbin must be made in such a way that there is no hazard to the cleaners, collectors or incinerator operators. Please remember that these persons have no expertise in this area and therefore all residues of dangerous materials must be removed from bottles before discarding the empties into the dustbin. If they are

to be incinerated closed containers must be opened or vented before disposal to prevent explosion. Waste bottles are provided for some solvents, which are then disposed of or recovered outside the laboratory. The dangers of incompatible chemicals should be kept in mind when using open laboratory bins. Great care should be taken when disposing of spent chromatographic columns as they may contain large volumes of solvent.

10.5.5 Incineration

Organic chemicals, including toxic and carcinogenic compounds, are frequently disposed of by burning as efficient, high temperature incineration destroys the hazards. Liquids can be made suitable for incineration by absorption on an inert material such as sawdust contained in a plastic bag. If there is any doubt about the complete safety of this operation, approval of a senior Officer and advice from the Safety Officer must be obtained.

10.6 Preventive and emergency procedures

This entails recognising the hazards of the chemicals being used and knowing the safety measures to be taken including emergency procedures.

Tidiness and cleanliness, good housekeeping and a high standard of personal hygiene are important in controlling hazards. Suitable protective clothing may be needed. Fume cupboard should be used for harmful chemicals, which are volatile, dusty or form aerosols. Spillage trays with absorbent lining and eye protection may be necessary when handling corrosive liquids. Safety screens must be used for work with explosive compounds.

10.6.1 Emergencies

Be prepared for any emergency that could arise having regard to any hazards of the chemicals to be used, for instance, where needed, have any specific antidote already prepared. The circumstances and action to be taken, including first aid, vary with the particular emergency so detailed reference sources must be available and followed on each occasion.

10.6.2 Spillages

Always have to hand the facilities for first aid, fire fighting and dealing with spillages and get to know the emergency procedures to be followed in each case.

10.7 Flammables and explosives

A potentially serious fire or explosion hazard exists with any material that is easily ignited, difficult to extinguish and which burns rapidly. All such compounds must be labelled with the appropriate warning notices.

The basic safeguards for controlling the fire and explosion hazard are:

a. Isolate the hazard -store flammables outside and away from other buildings.
b. Confine flammables - keep in closed containers.
c. Ventilate -to prevent accumulation of flammable mixtures
d. Install explosion vents if necessary.
e. Eliminate ignition sources and hot surfaces.
f. Post warning notices.
g. Plan experiments - check up on hazards and safe methods.
h. Examine equipment for defects.
i. Know location and use of correct fire fighting facilities.

10.7.1 Fire properties

Get to know the fire properties of flammable liquids. For instance the concentration range of vapour in air that will burn is defined by the lower and upper flammable mixture limits. The flash point of a liquid is the minimum temperature needed to generate a flammable mixture and is therefore the lowest temperature at which it will burn if ignited. The auto-ignition temperature is the minimum temperature at which the flammable mixture will self-ignite in the absence of spark or flame.

10.7.2 Flammable solvents

Flammable solvents should always be handled in well ventilated rooms or fume cupboards, where electrical apparatus is spark-proof (including switches and lights). They must never be confined where sparking occurs, for instance in or near refrigerators, ovens water baths etc. fitted with thermostats of a non-spark proof standard.

Flammable liquids must not be handled near ovens and furnaces as the surface temperature may exceed the auto-ignition temperature. Naked flames must not be used to heat vessels containing flammable liquids.

10.7.3 Highly flammable liquids

Extra precautions are necessary with highly flammable liquids (flash point below 32°C). For instance about 500 ml should be the maximum size of a solvent bottle allowed on the bench and the total stock of anyone solvent in the laboratory room should not exceed 5 litres. The liquid must be safely stored in lockable bins outside each building or in separate stores and only brought into the laboratory in small quantities as required. Inside the laboratory they must be kept in the suitable cabinet containers provided.

10.7.4 Gas cylinders

Wherever possible cylinders of flammable gases, e.g. hydrogen, acetylene etc. should be stored outside the building and piped into the laboratory work place.

If these cylinders are used in the laboratory, a prominent warning notice on the door of the room must indicate their presence. They must be kept outside the building when not in use, whether empty, part-filled or full.

10.7.5 Explosive mixtures

Many highly flammable gases and liquids form explosive mixtures in air and many more flammable substances become explosive in the presence of oxygen. Great care is necessary when working with potentially explosive systems to banish all sources of ignition such as heat and sparks.

If possible:

(a) always prevent the formation of explosive mixtures.
(b) avoid any very rapid evolution of gas or vapour.
(c) do not confine expanding gases e.g. from exothermic reactions.

10.7.6 Highly reactive substances

Mixing reactive substances can lead to explosion, e.g. strong acids and alkalis, strong oxidising and reducing agents; sodium metal or sulphuric acid and water. Only a few substances used in the laboratory are intrinsically explosive like perchloric acid, peroxides and azides. These unstable compounds need special protection from shock, friction or fire and instructions for their safe handling are contained in safety notices and advice notes supplied by the manufacturers.

10.7.7 Preventing explosions

Some general safeguards limiting explosions are:

a. Use small quantities of potentially explosive substances.
b. Avoid all forms of detonation and heat.
c. Use protective screens and face shields made of polycarbonate and not of acrylic material such as Perspex.
d. Install relief vents and handle by remote control where necessary.
e. Carefully control all cooling systems regulating exothermic reactions. The storage and handling of potentially explosive compounds requires careful attention (some useful general guidance on controlling this hazard is given in reference 6).

10.8 Corrosives

Chemicals like acids, alkalis, oxidising agents, bleaches, disinfectants, desiccants, cleansing agents, anhydrides and acid chlorides can attack and burn body tissues. Contact with them may cause no more than local irritation but even short contact with the concentrated from can cause permanent tissue damage.

10.8.1 Exposure

The overriding aim must be to eliminate or reduce to a minimum all contact with corrosives through the skin, eyes, nose and mouth. To avoid exposure to corrosive vapours use a fume cupboard whenever possible, or wear a respirator with the proper protective cartridge or use a well ventilated room. If there is any risk of splashing, wear the appropriate protective clothing such as gloves, waterproof gown or apron, face visor or spectacles.

10.8.2 First Aid

Washing with water is the best first aid treatment for most cases of body contamination by corrosives. Immediate and prolonged irrigation of the eye with water is essential to dilute and remove any chemical that has entered the eye. Alkali in the eye is particularly dangerous as it penetrates the cornea rapidly and deeply and is therefore difficult to wash out. Medical advice must be obtained immediately after an incident involving the eye.

10.8.3 Storage and use

Corrosive agents must be stored in robust bottles and containers in positions, which are easily reached. Wipe away the dribble on the bottle after use and stand the bottle on corrosion resistant trays or plates.

Avoid air displacement when pouring from narrow neck winchesters or cans by using a dispenser, which is designed to avoid spurting.

Some reagents such as fuming nitric acid and hydrofluoric acid act very quickly so an effective safety drill, particularly for the eyes, must be displayed nearby wherever these very dangerous substances are used.

10.9 Poisons

Chemicals can enter the body by ingestion, inhalation or through the skin. If taken in sufficient quantity all chemicals are harmful.

10.9.1 Toxic chemicals

Toxic chemicals can accumulate in the body unnoticed over long periods of exposure to low concentrations. In general the toxic effect is proportional to the concentration of the chemical and the length and frequency of exposure to it.

In order to reduce the toxic effect of chemicals there should be minimum exposure of people to chemicals. Do not use any toxic agent if a less harmful alternative will do. Some commonly used chemicals of underrated toxicity are:

a. Solvents such as benzene and carbon tetrachloride.
b. Metals like mercury, beryllium, barium or cadmium, and their compounds.
c. Reagents like phenols.
d. Gases such as carbon monoxide, hydrogen sulphide and nitrous fumes
e. Methanol

10.9.2 Ingestion

Eating, drinking, smoking and all cosmetic applications must not take place in the laboratory. All mouth operations like licking labels, sucking pencils should be avoided. Operations involving the use of by-mouth pipetting should not be practised in the interests of safety. If dangerous chemicals have to be used it is wise to have (if available)

suitable antidotes already prepared and a knowledge of how to use them. (see reference 6).

10.9.3 Inhalation

Wherever possible avoid all dusty operations and evaporations in air, which you must breathe. Many airborne chemicals are dangerous. For instance, dusts like asbestos and some forms of silica are toxic. Others, like many animal and vegetable dusts cause allergies. Harmful vapours, gases or droplets often originate from such common laboratory operations as solvent evaporation, gaseous evolution or the agitation of liquids (by whisking, bubbling or boiling etc.).

Use a fume cupboard, glove box or exhaust protective cabinet to avoid breathing any toxic solid, liquid or vapour. For less serious airborne hazards use a well ventilated room with the current of air blowing away from you.

It may be necessary to use proprietary detector tubes to monitor airborne hazards. The exposure levels obtained can be compared with published threshold limit values, which are the concentrations under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. The use of respirators and breathing apparatus is usually restricted to emergency situations, but they may be used in planned experiments if there is no other safe procedure.

10.9.4 The amount of absorption through the skin

The amount of absorption through the skin depends upon the area of exposure, the pre treatment and present condition of the skin, the particular properties of the chemical concerned and the solvent or carrier vehicle used.

Chemicals affect the skin in different ways. For instance, many solvents have a defatting action leading to dermatitis, whereas some chemicals sensitise the skin and give allergic reactions, whilst others such as phenol penetrate readily and act as systemic poison. To present or reduce skin absorption it is necessary to adopt a high standard of personal hygiene and to wear impermeable protective clothing.

10.9.5 Detailed descriptions

Detailed descriptions about the toxic properties of individual chemicals, emergency treatment for accidents and first aid procedures are given in reference 6, 7 and 8.

10.9.6 Carcinogens

(1) Storage, (2) handling in preparation of stock solutions and subsequent experimental work, (3) disposal of carcinogen contaminated material, (4) accidental spillage, and (5) identification, need to be considered.

Storage Preferably store all carcinogens segregated in one section of one refrigerator, in moisture-proof containers e.g. Kilner jars with silica gel indicator. For containers see also 10.2.5. For labelling see 10.3.

Handling Only handle preparations in one or at most two clearly defined areas of the laboratory, and exclude cleaners from these areas. The bench surface must be pre protected e.g. by disposable polythene sheets or Bench-Kote before containers are handled. Protective disposable gloves must be used and the use of suitable masks to prevent dust inhalation must be seriously considered. Transfer from container to container should be via disposable, if necessary hand-made, small wooden spoons (for solids) and hand pipettes (for liquids). These substances must never be mouth pipetted.

Disposal Left over stocks should not be disposed via the sink. Disposal via the dustbin or the incinerator should not take place. Trap left over liquids or small quantities of crystals in agar (in plates or small jars) before disposal. Wrap agar plates in robust polythene badges (500 gauge or better). Use rigid containers e.g. cast-off coffee jars for hypodermic syringes, pipette tips, wooden spoons and accidental split contaminated material. Contain all bags and jars in large robust polythene bags labelled 'CARCINOGENS' and arrange disposal as for radioactive materials. Non-disposable materials e.g. homogenizer blades, centrifuge tubes, filter units, should be cleaned by the experimenter following appropriate neutralising procedures for the given carcinogen (see Ref 9 for useful guidelines on waste disposal procedures) and must never be allowed to be recycled through the general laboratory facilities.

Accidental spillage This should be contained by the protective sheets described under handling. For general preventive measures see 10.6 for personal decontamination see 8.5.4. Report all accidental spillage to the Safety Officer for record purposes. Always be on the look-out for new information about toxic hazards. For example the unexpected formation of a potent carcinogen bis-chlormethyl ether from the interaction of hydrochloric acid and formaldehyde necessitates separating and limiting the vapour concentrations of these two common laboratory reagents.

Identification of carcinogens Check the entry for the compound in 'The Merck Index'. If the chemical is not listed, then check one of the following:

"lnformation Bulletin on the Survey of Chemicals being tested for Carcinogenicity" a World Health Organisation periodical publication obtained from International Agency for Research on Cancer, Lyon, France.

11.0 Hazards Of Ionizing Radiation

For full details please consult main departmental safety statement.

12. Non-Ionising Radiation

A number of laboratories now use sources of non-ionizing radiation, which may under certain circumstances, give rise to hazards. Such laboratories should ensure that the following points are taken into account.

12.1 Responsible person

There should be a responsible person available in the Department who is properly trained to recognise and correct any dangerous conditions or practices.

12.2 Instructions

Suitable operating instructions and information concerning the hazards should be provided to all staff and students concerned.

12.3 Warning notices

Appropriate warning notices, protective clothing and other necessary devices should be provided for areas of possible high exposure.

12.4 Surveillance

Medical surveillance should be required where appropriate and provision should be made for first aid and avoidance of further danger in the event of an accident.

The above are general points, to which should be added the following remarks concerning particular sources of non-ionizing radiation.

12.5 Lasers

The main hazard in the use of laser radiation is to the eye, though the skin is also at risk in the case of high power lasers operating in the infrared. Lasers of less than 1 mW do not present a serious risk though appropriate information and goggles should be made available for student use.

Lasers with a power output in excess of 5mW or an irradiate in excess of 2.5×10^{-3} watts cm^{-2} present considerable hazards and should not be made available to undergraduate students. Protective goggles must be worn in the use of such lasers. High power of pulsed lasers may present special problems and users should adhere closely to the internationally agreed recommendations of the EC or of the laser Institute of America.

12.6 Microwaves

The limit adopted should be l00 Wm^{-2} for continuous exposure and 10 W h m for intermittent exposure during any 0.1 h period. Mesh goggles should be provided where necessary and appropriate monitoring equipment should be available. Foil wrapping must never be placed in microwave ovens.

12.7 Ultraviolet radiation

There are many sources of ultraviolet light in science and medical laboratories. All users of such sources should restrict irradiances to less than 10 W m^{-2} for periods of more than 1000 secs. and total exposures to less than 10^4 J m^{-2} for shorter periods. The British N.R.P.B. recommendations should be followed pending the establishment of national requirements. When surveying gels on a uv transilluminator, goggles, face shield and gloves should be worn.

12.8 Sound and ultrasound

Ear protectors should be made available where the noise exposure may exceed 90 dB (A) for long periods during the working day. Attention should be drawn to the hazards presented by the use of ultrasonic cleaning baths and ultrasonic disintegrators.

13.0 REFERENCES

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FIRE REGULATIONS

FIRE EVACUATION DRILL

WHEN FIRE ALARM SOUNDS:

I. SWITCH OFF GAS TAPS AND ELECTRICAL APPARATUS IF SAFE TO DO SO.

II. LEAVE BUILDING IMMEDIATELY VIA NEAREST FIRE EXIT

III. DO NOT TAKE ANY PERSONAL BELONGINGS.

IV. DO NOT USE LIFT

V. WALK SWIFTLY - DO NOT RUN.

VI. OBEY FIRE MARSHALS' INSTRUCTIONS AND DIRECTIONS.

VII. DO NOT SHOUT OR BEHAVE IN ANY W AY LIKELY TO CAUSE PANIC

VIII. ASSEMBLE AT ASSEMBLY POINT.

IX. DO NOT RE-ENTER BUILDING UNTIL INSTRUCTED TO DO SO.

X. REPORT ANY SUSPECTED MISSING PERSONS TO FIRE MARSHAL.

YOUR CO-OPERATION IS NECESSARY TO ENABLE TOTAL EVACUATION OF THIS BUILDING DURING FIRE DRILL IN THE TIME ALLOCATED.

THE LIFE YOU SAVE MAY BE YOUR OWN.