Indira Gandhi National
Open University
School of Sciences

CLT-101
GOOD LABORATORY PRACTICES

Block

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LABORATORY ORGANISATION AND MANAGEMENT–I

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CLT-101: GOOD LABORATORY PRACTICES

LIST OF BLOCKS AND UNITS

Block 1 : Laboratory Organisation and Management–I

Unit 1 : Working in a Science Laboratory

Unit 2 : Important Components of a Science Laboratory

Unit 3 : Organisation of Laboratories: Preparation Room and Store

Unit 4 : Day-to-Day Management of the Laboratories

Block 2 : Laboratory Organisation and Management–II

Unit 5 : Stock Control and Purchase

Unit 6 : Files and Records

Unit 7 : Use of Computers in Laboratory Organisation and Management

Block 3 : Science Laboratory Safety

Unit 8 : Electricity and Gas Hazards

Unit 9 : Fire Hazards

Unit 10 : Chemical and Biological Hazards

Unit 11 : Personal Safety

Unit 12 : Accidents and First Aid

Please remember that this programme does not have any assignment component for continuous evaluation.

GOOD LABORATORY PRACTICES: INTRODUCTION

A laboratory is an integral and significant part of Science education used for carrying out the experimental work. Experimentation generates evidences for or against the theories in general and thereby enables a science oriented person to analyse the observations. The Schools are equipped with Biology, Chemistry and Physics laboratories for carrying out the experimental work. Each of these laboratories has dedicated laboratory staff that plays a very significant role in organizing and managing the laboratory work in an effective manner. Generally the job of a laboratory staff is to assist the teacher, provide help to the students, maintain apparatus and equipment and set up experiment for demonstration while following proper safety norms for general functioning of the laboratory. The person who wishes to work in a science laboratory should be trained towards all that is required for her/him to work in these laboratories.

The course **CLT-101** titled '**Good Laboratory Practices**' aims at imparting training to the laboratory staff towards designing, organising and managing the science laboratory with the help of theoretical background supplemented by a laboratory course, for skill development. This course is applicable to all types of School science laboratories and is **four** credits worth spread over **three blocks**. The first two blocks deal with **'Laboratory Organisation and Management'** where the basic aspects of design, organisation and management of science laboratories are discussed. The procedures related to material purchase and stock control are included. Due emphasis has been laid on record keeping and use of computers in the effective management of science laboratories.

Working in a laboratory may be hazardous if one works carelessly. The laboratory staff employed should know the hazards and also the safety measures to be followed for safe working of all those working in the laboratory. The third block on '**Science Laboratory Safety**' discusses the most common hazards that might occur in a laboratory and the precautions to avoid the same. It deals with the issues of safety viz. personal safety and first aid and remedial action a laboratory staff should take in case of an emergency.

Expected Learning Outcomes

After studying this course, you should be able to:

- appreciate the importance of science and scientific attitude while working in a laboratory,
- describe the main components, organisation and management of a science laboratory,
- explain the significance and use of computers in overall management of a laboratory,
- describe the common hazards encountered in a laboratory, the precautions and the safety measures that should be followed in case of an emergency situation.

Evaluation of CLT-101 Course

CLT-101 Course is worth **50 marks**. For successful completion of this Course, you must score at least 35% marks. The evaluation will be through a term-end examination held in the months of **June** and **December** every year. The duration of examination will be 3 hours. You are advised to contact your Study Centre for knowing exact examination dates.

BLOCK 1: LABORATORY ORGANISATION AND MANAGEMENT–I

A science laboratory is essential for all scientific disciplines for conducting experiment either to validate results of earlier studies/experiments or to provide new scientific information. It is important for persons working in a lab whether as a scientist or lab technician/assistant/attendant to have an idea of what science is and have a scientific attitude towards working in the laboratory. With this in mind, we begin the course by first discussing what science is and what is its importance, as this will help in inculcating a scientific attitude in the lab staff which is essential for efficiently assisting the students/teachers/scientists working in the lab. The crucial role that the lab staff plays in the smooth running of the laboratory is also emphasised. Next we proceed to the specifics of the main science lab and its associated structures, namely, the preparation room and store in which we first describe their basic components and essential features and then suggest methods for their effective organisation in order to manage them properly. The need for structural fittings and services (gas, water and electricity) in the main laboratory preparation room, store is also emphasised. Finally we describe the role and duties of the laboratory assistant/technician/attendant in helping the teachers/ scientists to smoothly manage the laboratory.

This block consists of four units.

In the first unit, **Unit 1: Working in a Science Laboratory**, we explain the concept of science and elaborate about its key features with the intention of helping you develop a scientific attitude which would be required at all levels when working in a laboratory, whether as a teacher or scientist or lab technician/assistant/attendant. The crucial role and duties of the lab staff in the laboratories for helping the teachers/scientists manage the students as well as the main laboratory and its associated structures is also elaborated in this unit.

In **Unit 2: Important Components of a Science Laboratory**, we discuss the essential components and features of a main science lab and its overall design. Beginning with the fixed and flexible designs, we introduce you to the concept of a laboratory unit which would enable you to estimate work space required by the students as well as the housing and storage of chemicals, equipment and miscellaneous items required by the students and teachers. Other essential features of the laboratory such as benching, surfaces and furniture, lighting, ventilation, heating and cooling services, flooring, security and safety are also discussed in detail.

In **Unit 3: Organisation of Laboratories: Preparation Room and Store**, we discuss the design and the requirements of space, storage, lighting and services that need to be provided in the preparation room and store room. In this unit, you will learn about the methods and ways of keeping equipment, chemicals and various items ready in the preparation room for immediate use when conducting the experiments in the main lab. The storage of equipments, chemicals and various other items in the preparation room and store will be dealt in this unit. Environmental and physical features, which are of prime importance in designing a store, have been described. Two appendices on storage and disposal specific to the store room have also been included in this unit

Organisation of practical work is the main responsibility of laboratory technicians. In **Unit 4: Day-to-Day Management of the Laboratories**, you will learn about organisation of practical work, demonstration, clean up and maintenance in biology, chemistry and physics labs. In this unit you will learn how to handle and manage lab services, emergencies and security issues that may occur in the labs.

Expected Learning Outcomes

After studying this block, you should be able to:

- describe the basic features of design and organisation of the main science lab and its associated units, namely, preparation room and store;
- manage the requirements of space, storage, lighting and services in the main lab, preparation room and store; and
- efficiently maintain, prepare as well as organise the various items required by the teacher and students for the practical work so that the lab functions smoothly.

UNIT 1

WORKING IN A SCIENCE LABORATORY

Structure

1.1 Introduction
Expected Learning Outcomes
1.2 Your Role in a Science Laboratory
1.3 What is Science?
Science as a Process of Inquiry
Features of Science
1.4 Science as a Way of Life
1.5 Approach to Your Work as a Laboratory Technician
1.6 Summary
1.7 Terminal Questions
1.8 Answers

1.1 INTRODUCTION

You must have studied science in your school. Can you recall some of the experiments that you did in the science laboratory? Did you enjoy doing experiments? You will agree that it can be a lot of fun for students if they can do interesting experiments in a properly managed laboratory. As a technician in the laboratory, you must understand that you are an important member of the team that runs science laboratories. So we begin this course by explaining your role as a laboratory technician in managing the laboratory and how important it is. If you understand this, you will be able to do your job better and help students enjoy 'learning by doing'.

We believe that you will be able to do your work as a science laboratory technician better if you have some understanding of what science is. You should also know how science develops and how scientists work to produce scientific knowledge. Understanding why laboratories are needed in science and why we need to do experiments will help you appreciate and understand how meaningful and important your work is.

You may feel that there is no need for you to know all this detail about science or scientific work. But you would do your work far better if you understand why you are doing it and why it is so important. This understanding will give you joy and success in your work in the lab.

Doing science gives us a set of values and leads to a particular way of life. This is called the scientific way of life or scientific temper. So, in Sec. 1.4 of this

unit, we explain what is meant by scientific way of life and the core values that follow from it. You must adopt these values and the scientific approach both in your profession and in your own life as explained in Sec. 1.5.

With this understanding of what working in a science laboratory means, you can learn the nitty gritty of your duties. In the next unit, you will learn how a science laboratory is organised.

Expected Learning Outcomes

After studying this unit you should be able to:

- describe the role of a science laboratory technician and explain why it is important;
- explain what science is and distinguish it from non-science;
- describe how scientific knowledge is gained;
- explain the importance of laboratories in scientific investigation; and
- outline the core values of scientific way of life and discuss why these are important in your work.

1.2 YOUR ROLE IN A SCIENCE LABORATORY

First of all, you must understand that your work is very important in a science laboratory. You are likely to work in physics, chemistry and biology laboratories (see Fig. 1.1). You have a vital role to play in the teaching-learning of these basic sciences.

(a) (b) (c)

Fig. 1.1: Basic Science Laboratories: a) physics; b) chemistry; c) biology.

With your help, teachers can make 'learning science by doing' a very enjoyable and rewarding experience for students. Here we would like to recall a Chinese saying:

I **Hear** and I **Forget**

I **See** and I **Remember**

I **Do** and I **Understand**

So concepts in science are learnt far better if students are allowed to explore, investigate and do experiments in the laboratory. Working in the laboratory gives you an opportunity to make the learning of science a rich and rewarding experience.

As a laboratory technician, your job is to help teachers in managing the laboratory in all possible ways. Your major duties will be to

- ensure daily cleanliness and maintenance of lab,
- handle, store and issue apparatus,
- keep the laboratory well-stocked,
- ensure that laboratory equipment and apparatus required for students are clean and in working order,
- maintain laboratory records and inventory for supplies and reagents,
- maintain utilities like water, electric and gas supplies in the laboratory,
- take care of safety measures, brief the students about laboratory safety and protecting their health while working in the laboratory,
- carry out minor repairs,
- assist teachers in setting up demonstration experiments and the overall management of lab,
- assist students in using apparatus appropriately,
- record observations, collect samples, prepare solutions, maintain records, write reports, and
- keep the laboratory in a good working condition at all times so that it is an inviting place to work in.

This list provides, by and large, the gist of your work. However, we would also like you to understand why your role as a lab technician is important.

You must play a positive role in your laboratory and give new ideas for improving its functioning. Working in science laboratories can be a very satisfying and rewarding experience if you approach it creatively. Remember, you will be helping in training young minds, some of whom may go on to become scientists later. Your work can also be challenging if you can think of better and newer learning activities to enhance the joy of learning science. Thus, you can contribute to make learning of science in the labs an enriching experience for both teachers and students.

To understand this point better, you need to understand how you should approach your work in the laboratory. It will help if you understand why you are doing what you are supposed to do in a science laboratory. So, if you understand what science is, how it develops, why laboratories are so vital in

the development of science, you will be able to appreciate why your role is crucial. This is what you will learn by studying the following sections.

You may now like to pause and reflect on what you have just studied. Try writing a few sentences in your answer to SAQ 1.

SAQ 1

What should your role as a technician in a science laboratory be?

Let us begin the remaining discussion by explaining what science is.

1.3 WHAT IS SCIENCE?

Before we explain what science is, it may be better if you first understand **what science is not.** Science is not a belief system or a faith, superstition or an individual's perception. It is not based on anyone's feelings, views or biases. You must know that science neither deals with supernatural phenomena nor attempts to explain them.

Physics, chemistry, biology, astronomy and earth sciences are the broad areas of natural sciences. It is worthwhile to note that mathematics is a formal science.

To understand what science is, just look at your surroundings. Think of the things you see that bring the word 'science' to your mind.

These could be the sun or the tube-light/bulb that provides light for you to see, the food you eat, the plants/trees and birds around you, your mobile or any other gadgets around you, and so on.

Science is knowledge of all these and more, in fact, *all living and non-living things* in the universe. These include stars and galaxies, the sun, earth and the planets and smallest particles in matter; the largest animals, trees and plants on the earth to its tiniest creatures; the rockets and satellites to nuclear reactors, human bodies and human minds that allow you to read and understand these words. Science refers to the body of knowledge about the entire **natural world** (Fig. 1.2).

Fig. 1.2: Science is the body of knowledge about the entire natural world.

The origin of the word science is from the Latin word “scientia”, which means knowledge. Scientists focus on the natural world and seek to find answers about natural phenomena. You may ask: What is the natural world? The natural world is what we sense directly or indirectly through our five senses, that is, sight, hearing, touch, smell and taste or with instruments that enhance our senses.

So, you have learnt that science is a body of knowledge about the entire natural world. But that is only one side of the story. What is it that makes science *what it is* and different from other branches of knowledge? Science is different from other bodies of knowledge because of the way it is done.

Science is also the process through which we gain knowledge about the natural world. Modern science is “a systematic process of inquiry” by which we try to understand how the natural world works and how it came to be that way. The knowledge gained through this process is the body of knowledge that we call science. So,

Science is both a body of knowledge and a process using which we *learn* about the natural world.

It is the systematic process of ‘doing’ science, through which the body of knowledge in science is gained and accumulated, that makes it different from other bodies of human knowledge such as art, literature, music, religion, etc.

You may now like to know: What is the process of ‘doing’ science? How do we gain this body of knowledge called science? What is the process of inquiry in science that makes it different from other branches of knowledge? We shall discuss this in the following section. Before that we would like you to check your understanding of what science is and what it is not.
Try SAQ 2.

SAQ 2

State whether the following statements about science are true or false?

a) Science is based on the belief of scientists.

b) Science is a body of knowledge of the natural world.

c) Science can deal with supernatural phenomena.

d) Science depends on the faith of individuals.

e) Science is a process by which knowledge about the natural world is gained.

1.3.1 Science as a Process of Inquiry

We will now explain the process of acquiring scientific knowledge.

Scientists explore and investigate the natural world using certain methods of inquiry. These involve a number of operations, both mental and manual.

The basic process of scientific inquiry begins by **asking questions**. These are usually based on **observations** of the natural world or arise from previous knowledge. We list below the main elements of this process:

- Making observations
- Asking questions
- Acquiring previous knowledge
- Proposing possible answer/framing hypothesis
- Doing experiments
- Analysing experimental results and drawing conclusions
- Sharing results with scientific community

Fig. 1.3: Sir C V Raman was born at Tiruchirapalli in Tamil Nadu on 7th November, 1888. His father was a school physics teacher and his mother, a home maker. After completing his graduation in 1904 and M.Sc. in Physics in 1907, he worked for a while in Kolkata and also did research on diffraction of light among other topics.

Note that the number and sequence of operations mentioned in this list can change depending on the subject/area of inquiry. We now briefly explain the various elements of the process of scientific inquiry with the help of examples.

❖ Making Observations

All of us, whether scientists or not, observe things, events and phenomena. In the past, people observed planets, constellations, eclipses, tides, changes in seasons, plants, animals etc. and decided when to move to better places, when to plant crops, when to celebrate festivals, etc. Even now farmers often separate the good seeds from bad ones by putting all of them in water. This is based upon the observation that good seeds sink and bad seeds float.

In science, we go beyond common observations and experiences, and try to understand how and why a phenomenon occurs. Therefore, in science, one needs to be clear about ‘what’ to observe and ‘how’ to observe it.

You may have heard of Sir C. V. Raman, the first Indian scientist to win the Nobel Prize in Physics (see Fig. 1.3). While on a sea voyage from Europe to India in 1921, Raman observed that the colour of water in the Mediterranean Sea was deep blue and wondered why it was so. Was it the reflection of the blue sky or was there some other reason?

Observations in science may be about natural events, for example, monsoons, change in climate, migration of birds, earthquakes, changes in galaxies, and so on. These could be about properties of materials in order to develop new materials, for example, rocket fuels or nuclear fuels, or for designing new machines.

Scientists have to make sure that their observations are not influenced by their sentiments and wishes. Scientific observations are then put in order, classified and recorded.

It is important for you to understand that **acquiring and employing the skill of systematic, detailed and accurate observation** is the first step in any scientific discovery.

❖ Asking Questions

When we observe any phenomenon such as an eclipse, we are curious to know what causes eclipse and so we ask a question. Even as a child you may have asked: Why is the sky blue? What is beyond stars and where does the universe end? Why do we see a rainbow after it rains? What causes

fever? How do images and sound come through television? We can have uncountable questions. Isn't it?

An unanswered question can prompt a scientific investigation. For example, how can a vaccine be designed for the common cold and cough?

Raman observed the colour of sea water and asked why it was deep blue.

❖ Acquiring Previous Knowledge

After posing a question, it is important to know if the question has already been answered or not. For an individual scientist, the question she/he answers or the problem she/he solves is often a logical extension of previous work. So it is important to explore previous knowledge which would lead to a more sophisticated understanding of the subject. It also allows us to make a decision about the relevance and design of an investigation.

Before C. V. Raman, the scientist Lord Rayleigh had proposed that the colour of the sea was just a reflection of the colour of the sky. In fact, the answer to Raman's question came from the knowledge of the previous work on the phenomenon of scattering of X-rays by A. H. Compton, an American physicist. This led Raman to think that the colour of sea water could be due to scattering of light by it. That was his possible answer or hypothesis.

❖ Proposing Possible Answer/Framing Hypothesis

Once an unanswered question is framed, scientists propose a possible answer. A possible answer is called a hypothesis in science. Hypothesis is generally built to answer a scientific question on the basis of reasoning. It is an intelligent/inspired guess based on observations, reason and previous findings/ experience on the subject.

For example, if it is observed that bees are attracted to flowers, a hypothesis may be that bees are attracted to flowers for their colour, nectar or both. Some more examples of hypothesis are: plants move towards sunlight, snakes possess the ability to hear, a body falls to the ground because it is attracted towards earth, etc.

A scientific hypothesis has to be tested and verified by experiments in laboratories or careful observations of natural phenomena in the universe.

❖ Doing Experiments

Experiments are carried out generally in laboratory or in the field. They are designed to verify, refute or validate a hypothesis. **Doing experiments is the most important element in the process of scientific inquiry**. That is why, an experiment is repeated many times to avoid errors. Scientists have to be certain of the accuracy of experimental results. It should also be possible for other scientists to reproduce and verify experimental results.

REMEMBER: Laboratories have a central role in the growth of science.

To illustrate the importance of experiments, let us continue the story of discovery of Raman Effect. By doing experiments on scattering of light by liquids, Raman was able to show conclusively that the colour of the sea was the result of the scattering of sunlight by the water molecules.

You may be surprised to know that the total cost of the apparatus used by Raman in his experiments was Rupees Two Hundred!

❖ Analysing Experimental Results and Drawing Conclusions

Experimental results/observed data have to be examined and analyzed to draw a conclusion. The hypothesis may be accepted or rejected. If needed, it may be modified and again put to test.

Analysis of Raman's experimental results led to many applications. With the invention of the laser, the 'Raman Effect' has proved to be a very useful tool for scientists to analyse the structure of materials.

❖ Sharing Results with Scientific Community/Scientific Reporting

An experiment or its analysis alone has no value unless it is shared with other scientists and is accompanied by a written report with an explanation, verification and a hypothesis. It is important that every detail of how an experiment was conducted is described in the report. *You will understand this point better when you learn how to write a report while doing experiments in the Laboratory courses of this programme*. When reporting experimental results, accuracy, honesty and clarity of presentation are essential.

Scientific results and explanations are always communicated by publishing in journals or presenting in scientific meetings. The reports or explanations are published after strict scrutiny. These are accepted only when a consensus has been arrived at by other scientists about their being valid.

If a new experiment proves the earlier results or explanations to be incorrect or incomplete, the earlier explanations are revised or may even be discarded. *Scientists do not stick to any explanation or theory unless these are tested by experiments and found to be valid, reported and accepted*.

Raman reported his discovery in a meeting of scientists at Bangalore on March 16, 1928. His discovery is known as Raman Effect.

So we find that a simple observation of the deep blue colour of Mediterranean Sea led to an important discovery known as Raman Effect for which Sir C. V. Raman was awarded the Nobel Prize in Physics in 1930.

To sum up, all over the world scientists working on a certain subject area communicate their findings by publishing them in journals. Over years, an organized body of knowledge in science develops based on the process described so far. It can be **tested** by anyone for further investigation. This knowledge is simplified, condensed and taught in text books and science laboratories to students studying science in schools, colleges or universities.

While we teach or learn science in school and colleges, it may seem to most of us like a collection of facts listed in textbooks. This is not entirely so. You have learnt that science is also a process of inquiry and discovery. It helps us to make sense of these facts to arrive at an understanding of the natural world and how it works.

We hope that from the discussion so far, you have got some understanding of how scientific knowledge develops. You may now like to revise the process of scientific inquiry before studying the next section.

SAQ 3

a) We have described the discovery of Raman Effect in different parts of this section. Answer the following questions about it:

   i) What observation led to the discovery of Raman Effect?

   ii) What was the hypothesis given by Sir C. V. Raman?

b) In each of the statements given below, identify the operation in the process of scientific inquiry (observation, hypothesis, conclusion) that it describes:

   i) In disease X, the chemical "A" is effective in around 60% patients.

   ii) Chemical "A' can be used to treat the disease caused by bacteria "B".

   iii) A chemical "A" is accidentally spilled into a dish containing bacteria "B" and kills most of them.

1.3.2 Features of Science

You have now learnt that science is a body of knowledge about the natural world and also the process of acquiring that knowledge. It is gained through a process of inquiry that involves **testing hypothesis on the basis of experiments and observations**. Due to this process of inquiry, science has many features that you need to understand so that you can help in improving the teaching-learning of science in your laboratories.

- **Science is ongoing and ever growing.** Science develops continuously. As newer tools of inquiry develop, observations can be refined and experiments repeated. New questions are thrown up and new answers come up. As an example, let us take the story of discovery of the atom's inner structure.

  After the discovery of electron in 1897, it was thought that atoms were like a plum pudding of positive charges with electrons lying in it like raisins (see Fig. 1.4a). Experiments done about ten years later led to this picture of an atom: that most of the mass and positive charge of an atom is concentrated in the centre in a very small fraction of its volume known as its nucleus. Electrons move around it (Fig. 1.4b).

  In the last one hundred years or so, refined tools have led us to refine our understanding of the atom's inner structure. The current understanding is that the atom's nucleus is made up of protons and neutrons, which are themselves made up of very tiny elementary particles called quarks. The electrons are distributed as 'charge clouds' of various shapes around the nucleus. The search continues.

  Similarly, our understanding of the universe has entirely changed in the last 500 years or so. It was believed in the ancient times that the earth was at the centre of the universe. Then about 500 years ago, on the basis of observations in astronomy, a model of the universe with the sun at its centre was developed. Now the use of sophisticated telescopes has led to the understanding that the universe has no centre and no boundaries.

  So, old models and conclusions change continuously in science as newer data and results come in. Therefore, science is always revisited, revised and /or improved. Each new observation/experimental result can throw up another set of new questions to be investigated.

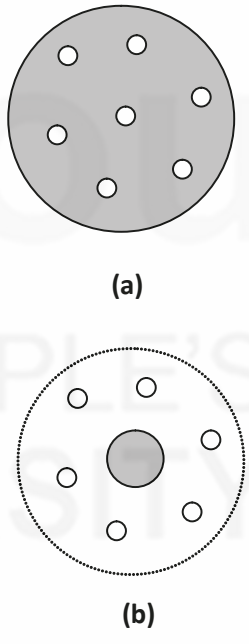


Fig. 1.4: a) Plum pudding model of atom; b) nuclear model of the atom.

This brings us to another feature of science.

- **Science is open to change.** Scientific ideas are accepted only after these have been tested through experiments. Therefore, science is **open** to change. Also, **science is not dogmatic.** If earlier ideas are proved to be wrong through careful experiments, science does not insist on standing by them. There is no notion in science that cannot be tested or challenged provided there is **evidence** to do so. In that sense, no scientist can claim that she/he has absolute knowledge of how nature works and cannot be questioned. Science is, therefore, self-correcting.
- **Science is objective.** You have learnt that the results of science can be repeated and verified by anyone anywhere if proper laboratories are available. To be accepted as science, all ideas must be tested and verified through observations and experiments. In that sense, it does not depend on the biases or opinions of some higher authority or select groups of individuals. No high authority or individual can save a theory in science if it is disproved by experiments or observations.

Finally, **modern science is a global human effort.** People all over the world participate as individuals or in groups in the process of creating scientific knowledge. And you can too, in the science laboratories that you work in!

So far, you have leant that science poses questions, generates ideas and constitutes a way of thinking. It involves observation and insight as well as reasoning and intuition. Science relies on testing ideas to see if the expected answers are correct. Ideas that are not testable scientifically now or in future, are not considered science. So, you have now developed an understanding of science as a body of knowledge, as a process of inquiry, as a human effort that has certain characteristic features.

The process of scientific inquiry and its features give a set of values and a way of life to those who follow it or who are involved in teaching-learning of science. We now briefly discuss this aspect of science.

1.4 SCIENCE AS A WAY OF LIFE

The features that characterise science give rise to a certain outlook or a way of life, an approach towards life of an individual or of society and a set of values.

Due to the reliance on testing and evidence for accepting any idea in science, this way of life does not adhere to biases. Science gives us an outlook which makes us think and act in a logical manner, reject superstitions, prejudices, and question preconceived notions and injustice. It also gives us integrity in the pursuit of better understanding. You have learnt that while doing science, we have to be objective. Otherwise, we cannot succeed in our investigations. If we are objective in our laboratories, why would we not be so in our daily lives?

Doing experiments in a science laboratory requires a lot of discipline, perseverance and patience, which becomes a habit of professionals in science. As you now know, scientific ‘truths’ are accepted after a lot of scrutiny and discussion. Therefore, tolerance for difference of views and approaches is an accepted way of life in science. The acceptance of the right to question and be questioned are part of a scientific way of life.

The term “scientific temper” was first used for this way of life and set of values in India by the first Prime Minister of India, Pandit Jawaharlal Nehru. Let us quote him from his book entitled the “ Discovery of India”:

“What is needed is the scientific approach, the adventurous and yet critical temper of science, the search for truth and new knowledge, the refusal to accept anything without testing and trial, the capacity to change previous conclusions in the face of new evidence, the reliance on observed fact and not on pre-conceived theory, the hard discipline of the mind – all this is necessary, not merely for the application of science but for life itself and the solution of its many problems”.

Science is thus a way of life, a process of thinking, a method of acting and associating with our fellowmen.

It is important to note that in ancient Indian texts we find that intellectual debates, dialogue, questioning, logical arguments, reasoning and discussions were a part of life in those times and were encouraged. In this regard the names of illustrious women philosophers, Gargi and Maitreyi, are well known. The Buddhist tradition and other traditions in Indian philosophy such as the Lokayata, Samkhya school, the Nyaya-Vaisesika schools and early Jain scholars emphasized reasoning, logic and the spirit of inquiry.

You may now like to take a break and think about what you have studied in this section.

SAQ 4

In each of the following situations, who amongst “A”, “B”, “C”, reflect a scientific way of life in their response?

a) On hearing from someone that a bright light had descended from the skies,

“A” believed the person and told others about it;

“B” questioned the person and tried to find out the facts;

“C” did nothing.

b) After listening to complaints about the work of a staff member working in a laboratory,

“A” did not pay any attention to them;

“B” suspended the person right away;

“C” conducted an inquiry to gather facts and then took a decision.

c) A student in the laboratory fell ill.

“A” took the student to the hospital after giving first aid;

“B” started praying to god;

“C” gave the student some medicine.

1.5 APPROACH TO YOUR WORK AS A LABORATORY TECHNICIAN

So far, you have learnt about what working in a science laboratory means, what science is, how it develops and what the scientific way of life is. You know that this way of life prevents us from being biased or adopting misguided beliefs. A scientific way of life is not limited to science laboratories or consuming available information. It influences the way we live our lives and approach our work. Therefore, in the last section of this unit, we briefly outline the approach you should adopt towards your work as a laboratory technician.

You have learnt about the importance of experiments and laboratories in scientific work and development of scientific knowledge. The foundation of this process is laid in school science laboratories when young minds are exposed for the first time to it. Therefore, how you approach your work is extremely important.

Working in a laboratory is actually very fascinating and engrossing activity. But you need to work seriously, attentively, and with patience and perseverance. You must keep in mind that laboratory work is not just some mindless manual work. You need to apply your mind and work very carefully and systematically. You must avoid chatting while doing any type of job in a laboratory.

You may like to adopt the values described in Sec.1.4 and try to be objective, open-minded, patient, tolerant and willing to help while dealing with students. Never scold students if they make mistakes. This can dishearten them. You too may make mistakes during your work. The important thing is to learn from your mistakes, not repeat them, and try to improve your work. You should be serious about your work. Always be encouraging and positive in your attitude.

Your interaction with students, your colleagues and teachers present in the lab has to be courteous and polite. There is no space for anger in individuals working in a laboratory as an angry mind is prone to illogical thinking and errors. Remember, you are a professional in a science laboratory and your work as laboratory staff is dignified and important. No laboratory can function without laboratory technicians. You should not think of it as a mechanical manual job.

You have learnt that you can also think up new ideas and help in improving the experiments. You should understand that the work of laboratory technicians is equally dignified as that of teachers and adopt the value of ‘dignity of labour’.

You should do your work with utmost honesty and integrity. Hard work and sincerity of purpose will go a long way in making your work satisfying for you. You should try out new ideas to enrich existing experiments. Never give up when faced with any difficulty. Take help and do not hesitate to ask questions if you feel that logic and reason are being ignored. This is what you have learnt in this unit about science and working in science labs.

Through your efforts, you can help in making teaching-learning of science a truly rewarding and enjoyable experience for your students. Remember, you

can nurture a scientific attitude in your students from a very young age so that they keenly practice it throughout life. That is why your work in science laboratories is truly important.

You too will undergo similar training as a student in this programme and we hope that these values, way of life and attitude will help you learn better.

Let us now summarise what you have learnt in this unit.

1.6 SUMMARY

- Science is a body of knowledge and a process of inquiry about the natural world. It is developed by scientists through a process of questioning, observation, building hypotheses, testing of ideas by doing experiments, and explaining experimental results. **Observation** and **experiments** are the main elements of the process of scientific inquiry. Ideas that are not testable through observations or experiments now or in future, are not considered science.
- Accepted scientific knowledge is considered to be reliable because it has been subjected to strict testing through carefully done experiments. But as new evidence is acquired through newer experiments and new knowledge is gained, the older ideas can be revised.
- The process of creating scientific knowledge gives science certain characteristics that make it different from other branches of knowledge. These are mainly that science is ever growing, open to change, not dogmatic, self-correcting and objective.
- Science poses questions, generates ideas and constitutes a way of thinking. It gives us a way of life that does not accept anything without testing, makes us change our notions in the face of evidence, and gives us discipline of the mind. It gives us a set of values that emphasise on truth, honesty, integrity, patience, tolerance for difference of opinion, discipline and dignity of labour.
- As a laboratory technician, you should approach your work by being objective, open-minded, patient, courteous, polite, tolerant and willing to help students. You must be willing to learn from your mistakes and do your work sincerely and honestly.

1.7 TERMINAL QUESTIONS

1. Describe the process of scientific inquiry with the help of examples.
2. Explain why laboratories are important in the development of science.
3. Outline briefly what you would do if:

   a) your student dropped a beaker and hurt herself?

   b) the teacher wished to demonstrate how plants need light to grow?

   c) a student could not set up the circuit connections properly?

   d) any apparatus was not found to be working?

   e) The lab was to be kept neat and tidy?

4. Explain in your own words what you understand by scientific way of life/ scientific temper.

1.8 ANSWERS

Self-Assessment Questions

1. You should write your own answer after studying Sec. 1.2.
2. a) False; b) True; c) False; d) False; e) True.
3. a) i) The colour of sea water is deep blue.
   ii) The hypothesis was that the Compton Effect applicable to scattering of X-rays must also be true for light.

   b) i) Conclusion.
   ii) Hypothesis.
   iii) Observation.
4. a) “B”; b) “C”; c) “A”.

Terminal Questions

1. Refer to Sec. 1.3.1 and answer in your own words.
2. Refer to Sec. 1.3.1 and answer in your own words.
3. Ideally, you should
   a) administer first aid immediately and then take the student to the Doctor. Under no circumstances should you scold her or show any anger.
   b) get the apparatus required for the experiment and set it up for demonstration as per the teacher’s instructions. You should try to give your inputs as well.
   c) check the circuit connections if you know them or advise the student to take help from the teacher.
   d) try to locate the fault and carry out repair, if minor. If it has any major fault, inform the teacher.
   e) keep the lab neat and tidy yourself and take help of the staff deputed for cleaning.
4. Refer to Sec. 1.4 and answer in your own words.

UNIT 2

IMPORTANT COMPONENTS OF A SCIENCE LABORATORY

Structure

2.1 Introduction
Expected Learning Outcomes
2.2 What is a Laboratory?
2.3 Lab Design and Space
Fixed Design Laboratories
Flexible Design Laboratories
2.4 Benching, Work Benches, Storage, Furniture and Computer
Benching
Work Benches
Storage
Furniture and Computer
2.5 Services and Drainage
Services
Drainage
2.6 Ventilation and Lighting
Ventilation
Heating
Lighting
2.7 Fume Cupboard
2.8 Access to and fro from the Laboratory
2.9 Security and Safety
2.10 Summary
2.11 Terminal Questions
2.12 Answers

2.1 INTRODUCTION

We believe that you have some experience of working in laboratories (abbr. singular- lab, plural-labs) while you were in your school. Can you recall the salient features of those laboratories and how they were organised? Did you find them convenient and safe to work in or did you feel that there was scope for improvement? Can you also recall the lab staff who were there and what duties they performed in the labs? The job of the laboratory staff is to assist in lab organization, maintenance and in most of the lab activities. They support teachers and students in doing practical work. It is important for the lab staff to first become familiar with the infrastructure, services, ventilation, lighting of the labs. This enables them to prevent any problems from occurring in the functioning of the labs, to safely carry out repairs and to keep the labs in good condition.

In the present unit, we will discuss the broad principles, underlying the organisation and design of a lab. We will also discuss the features of the main science lab in a school/college and the basic facilities, and services provided to it in order for it to function properly and efficiently. This unit will be followed by Unit 3 that deals with specialised rooms or units called ancillary structures or just ancillaries. These ancillaries are associated with the main lab in order to provide proper help and support to it so that it functions efficiently. In general, the main labs of a discipline like Biology, Chemistry and Physic would have ancillary units like a preparation room or store associated with them. In institutions where a separate preparation room or store is not available, an area in the main lab would be partitioned off or designated as a preparation area or store area.

Expected Learning Outcomes

After studying this unit, you should be able to:

- define a lab and explain its function;
- describe the function of the main lab and the structures called ancillary structures/ units or ancillaries that are associated with it;
- differentiate between a fixed and flexible lab design and describe on the basis of bench placement the two common lab design layout found in most school and college labs;
- list and briefly describe the common features of a lab that are: benching, work benches, storage, furniture, computer, drainage and provisions for electrical, water and gas services;
- give the difference between natural and forced ventilation and explain the importance of ventilation, heating and adequate lighting as well as give reasons for the use of fume cupboards in the lab; and
- describe the importance of quick and easy entry and exit from the laboratory and its work area and the need for security of the lab premises.

2.2 WHAT IS A LABORATORY?

Science Laboratories are used for practical work or demonstrations that help to explain and support theoretical concepts. A lab could just be a single room or a large building with separate rooms for specific lab work. A laboratory can thus be defined as, “a room or building fitted out for scientific experiments, research, teaching or the manufacture of drugs and chemicals”

The size of the lab depends on the purpose for which it is required. A private single owner pathology or microbiology lab, used for some routine medical tests is generally small. Public and private research institutions have several large labs.

Schools usually have separate main laboratories for chemistry, physics, and biology. In this unit we will use the term “Main Lab” for the room where students carry out experimental laboratory work.

The usage of the term “laboratory” varies as it can be used for naming large research institutions such as the National Physical Laboratory (NPL), Delhi (Fig. 2.1), the National Chemical Laboratory (NCL), Pune and the Regional Research Laboratory at Hyderabad. There are also pharmaceutical laboratories for manufacturing drugs. The term is also used for a single room if it is equipped for performing experiments.

Fig. 2.1: National Physical Laboratory, New Delhi.

2.3 LAB DESIGN AND SPACE

Laboratories have different design features which depend on the type of work or experiments that are to be performed in them. For example, a chemistry lab (Fig. 2.2) is different from a biology (Fig. 2.3), physics (Fig. 2.4) or computer science lab.

Fig. 2.2: A view of a chemistry laboratory with fixed design. Chemistry students perform their experiments while standing.

Fig. 2.3: **A view of a biology laboratory. Biology students perform their experiments while seated.**

Fig. 2.4: **A view of a physics laboratory with a flexible design. Physics students perform some of their experiments while standing and some while seated.**

2.3.1 Fixed Design Laboratories

The main lab in schools and colleges are usually rectangular in shape as shown in Fig. 2.5. The typical size of a lab is somewhere between 40 and 80 square metres.

The space of the laboratory could be of (i) fixed or (ii) flexible design.

A fixed design lab is suitable for a teaching institution like schools or colleges. The general design of the lab is fixed and permanent, so changing the lab layout is not possible. Fig 2.2 shows a lab with fixed design. In fixed laboratory design the benches, cupboards and services are rigidly fixed as follows:

Services mean gas, water and electricity.

i) The lab tables which are called benches are firmly attached to the floor and, perhaps also to the walls.

ii) The supply lines of services like electricity, gas, water are usually screwed and clamped to bench legs and the underside of the fixed lab benches.

2.3.2 Flexible Design Laboratories

In flexible lab design the furniture lab benches and supply lines of services are free-standing so that they can be easily moved. In such labs the layout can be changed or modified. Flexible designs are quite suitable for private multipurpose labs. Fig 2.3 as given above shows a flexible lab design.

It is important for a lab to have adequate space within which the students can work conveniently. Ample space is required to safely conduct lab work and also for efficiency and lab maintenance. Over crowding in the lab contributes to lab accidents. As a lab assistant you may have to calculate the number of students that can be accommodated in a given lab. The student enrollment in India is quite high in schools and therefore it is difficult to assign a lot of space to each student. We suggest that a minimum of two metres bench space should be allotted per student as this would be sufficient space for work, circulation and safety.

SAQ 1

What are important features of a flexible lab?

2.4 BENCHING, WORK BENCHES, STORAGE, FURNITURE AND COMPUTER

The placement of work benches in a laboratory is termed as benching. The benching arrangement in a lab determines its design layout.

2.4.1 Benching

A school or college lab may have various possible kinds of benching arrangement, which means how work tables/benches are placed in the lab. Fig. 2.5 a and b shows the possible arrangements of work benches in a lab.

Fig. 2.5a shows a benching design consisting of perimeter and island benches. In this design, work benches are placed along the three sides of the perimeter of the laboratory and so are called perimeter benches. Island benches are placed in the middle. This arrangement allows a large number of students to use the lab and is ideal for a school or college lab. Fig. 2.5b shows only peninsular benching, in which the width side of the work benches are fixed against one wall and the benches extend up to two thirds of the lab space, leaving a corridor type of space at one end. This design is more useful when the batch of students is small.

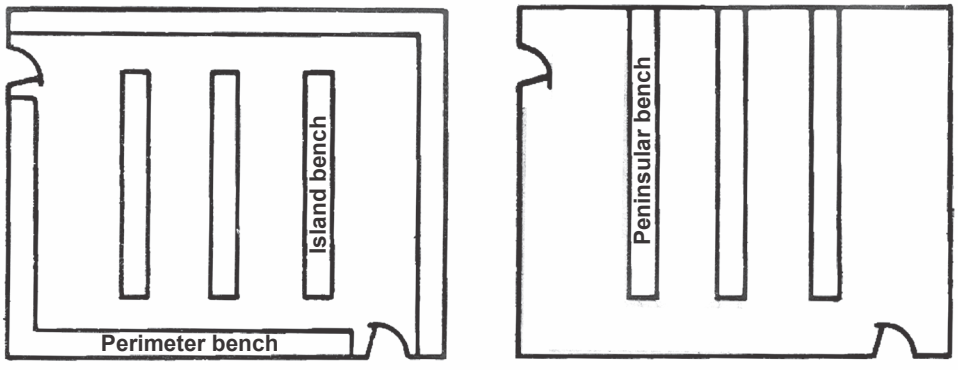


Fig. 2.5 Possible of benching layouts in a school or college lab: a) Perimeter and island benching; b) Peninsular benching.

2.4.2 Work Benches

The kind of bench top or work surface provided is according to the type of lab work that is to be done. In general bench tops should be impervious to water and damage and should be resistant to disinfectants, acids, alkalis, organic solvents and moderate heat. The bench surface could be of timber (solid wood)/PVC/Kota stone/granite/glazed tiles/formica or metal. The surface of the bench tops in a biology lab should be resistant to acids, alkalis and stains and should be able to withstand moderate heat. Furthermore it should be of a material which can be easily and effectively sterilized. The work surface of a chemistry lab should also be able to withstand moderate heat and should be resistant to strong acids and alkalis or other corrosive chemicals while the work surface of a physics lab should be of an insulated material. The lab staff is expected to make sure that bench tops are not damaged by the students and are appropriately maintained.

The height of the work benches in the labs also depend on the kind of work to be done. In case of a biology lab where the practicals are done in sitting position the height of the benches are shorter in comparison to the chemistry lab where practicals are conducted in standing position or a physics lab where work is done both in sitting and standing positions. However for a lab of a particular discipline the dimensions of the work benches both in terms of height and width is generally standard even though people working in the lab may be of different height and build.

2.4.3 Storage

In the main lab good storage facilities are essential, firstly to hold supplies for

immediate use, secondly to prevent clutter on bench tops and in the aisles and thirdly for storage of apparatus and equipment which are expensive and delicate and are used often. Thus in the main lab only equipment and consumables required for day-to-day use are stored. An obvious exception would be specialized large equipment, like an ultra centrifuge which may have to be housed in the lab even though it is used only occasionally.

In the main lab most of the storage area is at the bench top, under the bench (Fig 2.6) and along the walls. Storage units on the bench surface, under the bench and along the walls are properly planned and installed, according to the nature of the lab work.

Fig. 2.6: **Under bench storage.**

The storage units may have open or closed shelves. Many shelving units in a lab are dedicated to storing chemicals. For example in a chemistry lab open shelves are used for keeping bottles required for daily practicals (Refer again to Fig.2.2). Open shelves are placed between two benches so students working on either bench can use them.

Additional long-term storage space may be provided in a partioned or specially designated area within the main lab or may be located outside the main lab in a store.

All the storage or units, particularly the under-bench storage units need to be checked and cleaned periodically, otherwise expired or outdated chemicals and items that should have been discarded earlier get collected. It is important

for the laboratory staff to inform the academic staff associated with the lab about the outdated equipments and chemicals so that they can take the necessary official steps for their disposal.

2.4.4 Furniture and Computer

The main lab is also provided with office furniture such as a table and chairs which are required for the teachers conducting the lab sessions. Now a days a computer table along with a computer is also provided so that the teacher can give a power point demonstration or show videos that supplement the lab practical. Stools are provided in all types of labs irrespective of the fact that the student may be doing his experiments in a sitting or standing position.

SAQ 2

a) List the type of materials used for bench surfaces.

b) In the following statements fill in the blank spaces with appropriate words.

   i) Peninsular benching design is more useful when the batch of students is .....

   ii) The storage units may have ..... or ..... shelves.

2.5 SERVICES AND DRAINAGE

The services that are required in a lab include water, electricity and gas supply. Not all services are required in every lab. Electricity is required in all labs. Water and gas are usually not needed in a physics lab but are required for a biology and chemistry lab, for which gas outlets and sinks with water taps are provided at the work benches. Some labs such as chemistry labs may also have specialized services such as steam, vacuum or compressed gases. Fume extractors may be provided in some specialised chemistry and biology labs.

2.5.1 Services

The electricity, water and gas services in both fixed and flexible labs are almost always provided by means of the floor and run along the benches. Their outlets are fixed at the surface of the work benches and so form an integral part of the work bench (Fig.2.7). The work space for each student would have all the service units needed for the lab practical work to be done. The walls of both a fixed and flexible lab are always fixed so that the supply lines for the services can be fixed within or on them. Within the lab however, in case of a fixed lab the supply of services on the benches can be by the floor or by the roof but in case of a flexible lab which is equipped with movable service stations service lines are provided only via the floor.

For safety purposes, the main switches for the control of services are located away from the lab area, generally outside the labs so that these can be turned off with ease in case of an accident or in an emergency situation.

There may be variation in the type of design or method of installation of services selected for a lab, however services are required to be installed in accordance with the recommended safety standards.

The lab staff must keep in mind the location of the main switches situated outside the main lab, the supply lines of the services going from the main switches to the labs and also the main service outlets in the lab that supply the work benches. It is important for the lab staff to periodically inspect the layout of services so that they can be properly maintained.

2.5.2 Drainage

Drainage In both fixed and flexible labs are provided at the end or sometimes in the middle of the benches. A proper drainage system is an integral part of all labs. The drainage pipes used in the lab are usually of a material which is particularly resistant to corrosion and can be readily cleaned.

Faulty or clogged drainage system is dangerous as it can lead to a wet floor which can be slippery and is risky for staff and students as they may fall and get hurt. Furthermore a wet floor may also be a cause of electrocution. Therefore the lab staff needs to periodically check the functioning of the drainage system in order to prevent clogging which could lead to a wet floor or flooding of the lab. Clogged drains therefore, must always be cleared immediately.

Fig. 2.7: Proper placement of electricity, gas and water outlets on the work bench.

SAQ 3

Indicate which of the following statements are true or false? Write T for true and F for false in the given boxes.

i) Gas, water and electricity are a must for any lab.

ii) For safety reasons the main switches for the services should be near the work benches.

iii) The electricity, water and gas services in both fixed and flexible labs are almost always provided by means of the floor and run along the benches.

iv) Services to the work benches are always provided from the roof.

v) In the following statements fill in the blank spaces with appropriate words.

a) The drainage pipes used in the lab are usually of a material which is particularly resistant to ..... and can be readily cleaned.

b) Faulty or clogged drainage system is dangerous as it can lead to a wet floor which can be ....., can cause electrocution, and could also lead to .....

2.6 VENTILATION AND LIGHTING

Ventilation, temperature conditions and lighting affect the environment of the lab. Proper ventilation, and comfortable temperature and lighting are essential for health and safety as well as for efficient working in the lab. It is therefore, important for the lab staff to know the provisions and connections that have been made for ventilation, heating, cooling and lighting in the lab and to ensure that they are in working order.

2.6.1 Ventilation

Indoor quality of air in the lab is essential. This is maintained by a proper ventilation system. The purpose of ventilation is to protect the students, teachers and lab staff from being overexposed to hazardous laboratory chemical fumes, excess heat due to ovens, hot plates, Bunsen burners, body heat, etc. Proper ventilation controls humidity which results due to respiration, steam baths, etc. Working conditions that are too hot or too cold or too humidity or too dry can be extremely uncomfortable and may lead to accidents. Thus control of all these factors by means of ventilation is important for a safe and comfortable working environment.

Ventilation can be provided by (i) natural or (ii) mechanical means.

i) Natural ventilation

Windows are provided in the lab for ventilation (Fig.2.8) but they provide an uncontrollable flow of air. Furthermore air from outside which comes through the windows often brings in unwanted draughts and dust which can disturb and damage the apparatus kept on the bench tops. The unwanted draughts and dust also adversely affects the efficiency of the people working in the lab. In addition to this, windows may not be useful in extreme climatic conditions. The opening and closing of the windows are thus dependent on the factors mentioned here.

ii) Mechanical or forced ventilation

In most labs therefore, even though windows are present, mechanical ventilation is provided by means of exhaust fans and/or ceiling and/or side fans (Fig.2.8) or air conditioners. All these types of ventilation systems produce a more constant flow of air and avoid the problems of open windows.

a) *Exhaust fans*

Exhaust fans are usually installed in the windows or above the window. These exhaust fans get rid of the hazardous chemical fumes, excess heat

produced due to ovens, hot plates, Bunsen burners, body heat etc. and also help in controlling the humidity generated due to respiration, steam baths etc. Installation of reversible exhaust fans provide better ventilation as they can also be used to draw in fresh air from outside.

b) *Ceiling/sidewall fans*

The ceiling and sidewall fans help in circulating the air within the lab and in lowering the temperature of the lab. Both these types of fans also help in reducing the humidity of the lab.

c) *Air conditioning*

Air conditioning units are also an example of forced ventilation. The air conditioning units control ventilation, temperature and humidity by supplying air that has been heated/cooled, dried/dampened in a series of accurate processes. This form of controlled ventilation provides the most acceptable way of controlling the lab environment. However, most school and college labs may not be provided with an air conditioner as it is very expensive though they will have fans for air circulation. Nowadays however some private schools and colleges may have provision for air conditioning. Generally though, air conditioning units are provided in industrial or research labs.

2.6.2 Heating

In most parts of India the winters are mild, but in areas that are very cold, heating arrangements for the lab are made by means of heaters. It is important to make sure that the heating system does not pose a danger by creating a hazardous atmosphere. Some modern air conditioning units nowadays are also able to heat the labs to the desired temperature.

The lab staff has to ensure that the various ventilation systems- windows, exhaust fans, heaters and air conditioners are in working order. They should also periodically clean the windows and the various types of fans provided in the lab.

Fig. 2.8: Arrangement for ventilation, cooling and lighting in a laboratory.

2.6.3 Lighting

We know that adequate lighting is necessary for any kind of work. Natural lighting provided in the lab by means of windows and sky lights is most suitable for the lab work but is generally inadequate. Lighting in labs is thus, usually supplemented by tube lights.

The amount of light required in a lab depends on the design of the lab. Good illumination is required for all kinds of activity, however, extremely bright or low lights or sudden contrasts in type of lighting may lead to tired eyes, cause headaches, and increase the incidence of accidents. The position of the light sources and the types of lights installed should be such, so that there is an effective distribution of light throughout the lab without there being any undesirable reflections and glare.

SAQ 4

a) List the various ventilation systems that were available in your school lab.

b) Indicate which of the following statements are true or false? Write T for true and F for false in the given boxes.

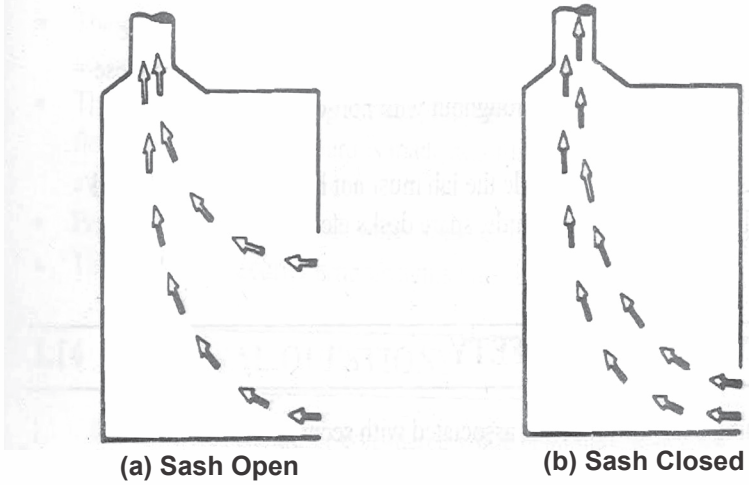
   i) Windows provide proper ventilation and light in the lab.

   ii) Reversible exhaust fans provide better ventilation as they can also be used to draw in fresh air from outside.

   iii) Extremely bright light is useful in a biology lab.

2.7 FUME CUPBOARD

Fig. 2.9 a, shows a simple fume cupboard. Any work involving noxious fumes is carried out in a fume cupboard. The design of a fume cupboard is very important. The fume cupboard should be such that it ensures an adequate flow of air whether its door/window is open or closed (Fig.2.9 a and b). With the sash open draught at the work surface is considerably reduced, whilst with the sash closed, air near the top is virtually static.



(a) Sash Open (b) Sash Closed

Fig. 2.9: (a) Circulation of air in a fume cupboard in (a) sash open position (b) sash closed position.

SAQ 5

Give the main function of a fume cupboard.

2.8 ACCESS TO AND FRO FROM THE LABORATORY

All labs are designed in such a manner so that the lab workers are able to enter as well as exit the lab and its work area quickly, in case of an emergency. For this purpose all the main labs as well as its associated structures (ancillaries) are provided with a minimum of two doors that are widely separated, so if an accident occurs near one of the doors of the lab then the persons inside the lab can escape from the other door. Within the lab easy movement for entry and exit of the workers is ensured by placing the benches in such a manner so that there is sufficient distance between them.

In addition to this, the building housing the lab is usually provided with several escape routes. For example the building should have more than one set of stairs and these should preferably be constructed of non-combustible material.

The lab staff should ensure that the access routes both outside as well as inside the lab is not be blocked or hindered in any way. This means he/she should not allow cupboards, spare furniture etc. to be kept in the corridors.

2.9 SECURITY AND SAFETY

Laboratories have expensive equipment and hazardous chemicals and so problems associated with security and vandalism are taken into account. Doors should be fitted with security locks, and the rooms should be kept locked when not in use. Windows on the ground floor should also be provided with grills and locks.

In all labs, escape routes are provided in case of emergencies. Refer to Unit 4 of Block 1 in CLT-101 where security measures in general as well as in relation to prevention of vandalism have been dealt in greater detail.

SAQ 6

a) Why should a lab have at least two doors that are placed at a distance from each other?

b) Why is it essential for a lab to be secure? List the security measures that need to be adopted for making the lab secure.

2.10 SUMMARY

A science laboratory of any discipline- biology/chemistry/physics is used for practical work or demonstrations that help to explain and support theoretical concepts.

A laboratory is defined as, “a room or building fitted out for scientific experiments, research, teaching or the manufacture of drugs and chemicals”.

A lab could just be a single room or a large building with with several separate rooms for specific lab work."

Schools and colleges usually have separate main laboratories for chemistry physics, and biology. The main lab of a discipline like Biology, Chemistry and Physic would have ancillary units like a preparation room or store associated with them. These ancillaries provide proper help and support to the main lab so that it functions efficiently. In institutions where a separate preparation room or store is not available, an area in the main lab would be partitioned off or designated as preparation area or store area.

The layout design of a lab may be of: i) fixed or ii) flexible type. In fixed lab design the work benches and service lines are fixed to the walls or/and floor and so the placement of the work benches is fixed while in flexible design the work benches can be moved.

The general features of the main lab of any discipline include the type of benching, the dimensions of the work benches, which depends on the type of practicals to be conducted, and various kinds of storage facilities, furniture and computer.

Electricity, water and gas are the important services that are provided to a lab. Outlets of these services are given at the surface of the work benches. Labs of all discipline are supplied with electricity. Water and gas may not be needed in labs of some discipline. Drainage is an important aspect of labs that are provided with water supply and so drains should be kept clean in order to prevent overflow.

Ventilation, temperature conditions and lighting affect the environment of the lab. Proper ventilation, comfortable temperature and lighting are essential for health and safety as well as for efficient working in the lab. It is therefore important for the lab staff to know the provisions and connections that have been made for ventilation, heating, cooling and lighting in the lab and to ensure that they are in working order. Ventilation can be provided by (i) natural or (ii) mechanical or forced means. Natural ventilation is provided in labs by windows but these produce an uncontrollable flow of air and so are not very useful for proper ventilation. Mechanical or forced ventilation is provided by means of exhaust fans and/or ceiling and/or side fans or air conditioners. All these types of ventilation systems produce a more constant flow of air and avoid the problems of open windows.

Heating is essential in labs that are in very cold areas. Heating arrangements for the lab are made by means of heaters. Nowadays some modern air conditioning units are also able to heat the labs to the desired temperature.

Adequate lighting is necessary for all kinds of work. Natural lighting in the lab is provided by windows and sky lights and is most suitable for the lab work but it is generally inadequate. Good illumination is required for all types of practical activities. Lighting in labs is thus, usually supplemented by tube lights. The amount of light required in a lab depends on the design of the lab.

In any lab, work involving noxious fumes is carried out in a fume cupboard.

All labs are designed in such a manner so that the lab workers are able to enter as well as exit the lab and its work area quickly, in case of an emergency. For

this purpose all the main labs as well as its associated structures (ancillaries) are provided with a minimum of two doors that are widely separated. The lab staff should ensure that the entry and exit points both outside as well as inside the lab are not be blocked or hindered in any way. This means cupboards, and spare furniture etc. should not be kept in the corridors. The building housing the lab is also usually provided with several escape routes.

Laboratories have expensive equipment and hazardous chemicals and so should be secure. In order to keep the lab premises secure and to prevent vandalism the lab doors are fitted with security locks, and the labs are kept locked when not in use. Windows on the ground floor should also be provided with grills and locks.

2.11 TERMINAL QUESTIONS

1. Describe the features of a fixed lab.
2. Define a lab. Explain with the help of figures how perimeter and island benching differs from peninsular benching.
3. List the services that are present in a chemistry lab of a school. What could happen if the drainage system in the lab gets clogged?
4. List the various mechanical ventilation systems that are used in a lab and describe any one of them.

2.12 ANSWERS

Self-Assessment Questions

1. Refer to subsection 2.3.2 for help.
2. (a) Refer to subsection 2.4.2 (b) (i) small (ii) open, closed.
3. (i) F (ii) F (iii) T (iv) F (v) (a) corrosion (b) slippery, flooding.
4. a) You have to write this on basis of your recollection but refer to section 2.6.1 for help.
   b) (i) F (ii) T (iii) F
5. Lab work involving noxious fumes is carried out in a fume cupboard.
6. a) Refer to section 2.8
   b) Refer to section 2.9

Terminal Questions

1. Refer to subsections 2.3.1 and 2.4.2.
2. A laboratory is defined as, “a room or building fitted out for scientific experiments, research, teaching or the manufacture of drugs and chemicals”. A lab could just be a single room or a large building with several separate rooms for specific lab work.” Refer to subsection 2.4.1.
3. Refer to subsections 2.5.1 and 2.5.2.
4. Refer to subsections 2.6.1 and 2.6.2.

UNIT 3

ORGANISATION OF LABORATORIES: PREPARATION ROOM AND STORE

Structure

3.1 Introduction
Expected Learning Outcomes
3.2 Importance of a Preparation Room
3.3 Components of a Preparation Room
Wet Bench
Dry Bench
Work Area
Storage
Proper Lighting and other Services
3.4 Access to the Preparation Room
3.5 Work Flow in the Preparation Room
3.6 Microbiological Preparation Room
Access to microbial Preparation Room for Bacteria and Fungi
Sterilizing Equipment
Preparation Area
3.7 Store and the Flow of Materials
3.8 Arrangement of Stores
Environmental Considerations
Physical Considerations
3.9 Flexibility of Store Design
3.10 Safety Provisions
3.11 Labels: A Cautionary Note
3.12 Recommended Storage and Disposal Procedures
3.13 Summary
3.14 Terminal Questions
3.15 Answers

3.1 INTRODUCTION

In the previous unit (Unit 2) you have studied about the broad principles underlying a good laboratory design. You have also studied that a laboratory could be of fixed or flexible type. You were also familiarised with the various components of a standard laboratory and their ideal placement within the lab. The kinds of services like water, gas and electricity needed for a lab were also explained to you. In addition to this you learnt that the main laboratories usually have adjacent rooms or rooms close by called preparation rooms and stores which function to provide service to these main laboratories and so these are built according to the type of laboratory and their specific requirements.

In this unit, we will discuss the basic design and organization of a general preparation room as well as a specialized preparation room namely, a microbial preparation room. Both these preparation rooms are planned in such a way that they are able to provide proper support to their respective laboratories. This is only possible if the preparation rooms are provided with suitable items and service facilities that are arranged in such a manner so as to allow the preparation rooms to fulfill their functions efficiently, thus providing proper support to their respective laboratories.

Stores cannot be considered in isolation, since the design of the laboratory and the store are inter-related. In this unit, we will also discuss the basic principles of the design of stores as well as typical ways of providing storage. You should bear in mind that the material in this unit inevitably has implications for other units dealing with the general subject of laboratory organization. An important section is included in this unit on recommended storage and disposal procedures of materials stored in the labs or preparation room or stores.

In some cases, it is more important that you are aware of sources of information rather than precise details and, therefore, two appendices have been included on storage and disposal. If in doubt, always seek advice.

Expected Learning Outcomes

After studying this unit, you should be able to:

- explain the interrelationship between the laboratory and the preparation room and store;
- explain the need for a standard preparation room, and a specialised preparation room such as a microbial preparation room for bacteria and fungi;
- explain the basic principles for the design of an efficient layout of the preparation room and store;
- list the main components as well as essential services that are required in a standard preparation room, a microbial preparation room and a store;
- explain why the location of a preparation room and a store has to be determined in advance; also why access to the preparation rooms and stores should be controlled;
- state the problems of storage of equipments, chemicals, apparatus and paper in the preparation room and describe how they could be overcome by efficient storage methods;
- list and write functions of the three main types of stores or three main areas designated in a single store which are required for efficient handling of goods received or dispatched; and
- describe how goods and materials in the store can be efficiently stored and explain the importance of controlled environment in the store.

3.2 IMPORTANCE OF A PREPARATION ROOM

Most of you may have some experience of working at a private lab or at a lab in School/College or University level. If so, then you may be able to recall that

the main laboratories usually have an adjacent room or a room close by called the preparation room that serves both as an extension of the main lab and also provides service to it. This is because a laboratory should only contain the minimum amount of equipment required for its needs while the rest should be kept in the preparation room. For example, a biology laboratory should contain only a selection of glassware in common use (flasks, beakers, burettes etc.) plus balances, pH meter and other large items that are in common use. All other items must be kept in the preparation room which is used in association with the main laboratory (Fig. 3.1). In most schools and in some industrial research sector however, an area in the laboratory itself is designated as the preparation work area in which some preparation work is conducted. In other instances also usually at school level a single room may be used both as preparation room and store. In colleges and research labs separate rooms close to the main lab are designated as preparation room and store.

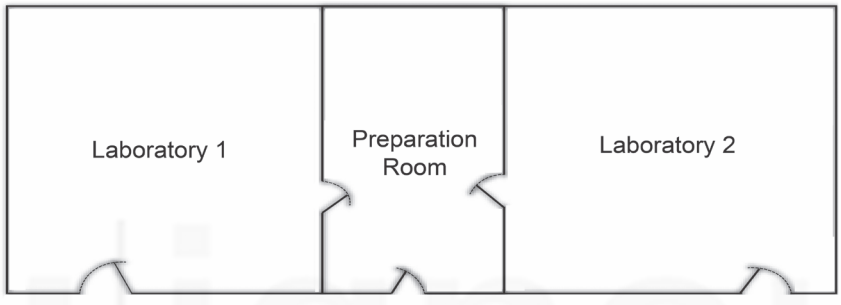


Fig. 3.1: Typical Relationship between the Preparation Room and Laboratories.

Preparation rooms are an essential part of teaching, research and industrial labs as most of the preparation work that is required for the conduct of experiments and demonstrations in the main lab is done there (Fig. 3.2). In addition to this, administration work associated with labs are usually done in preparation rooms. The preparation rooms often also play an important role in storing a range of equipment and apparatus which are not in continuous use. They are also often used for storage of extra quantities of chemicals and reagents.

A badly organized preparation room is rather like a badly organised kitchen. Time is often lost looking for items which should be easily available at hand. In a kitchen this results in frustration. In a lab it leads to a loss in efficiency and effectiveness and this in turn results in waste of money. A badly organised kitchen may also produce poor quality food. A badly organised preparation room may produce inaccurate solutions which may give inaccurate or poor results.

Fig. 3.2: A preparation room which is associated with a Zoology laboratory.

SAQ 1

What is the function of a preparation room?

3.3 COMPONENTS OF A PREPARATION ROOM

The role of the preparation room as we have explained is extremely important and so it should be an essential feature of the building plan of the entire building that have labs.

As you will study later in the unit, the design of the preparation room as well as what it contains, depends mainly on the type of main lab. However, all preparation rooms need to contain certain basic items and facilities in order to function properly (Fig. 3.3).

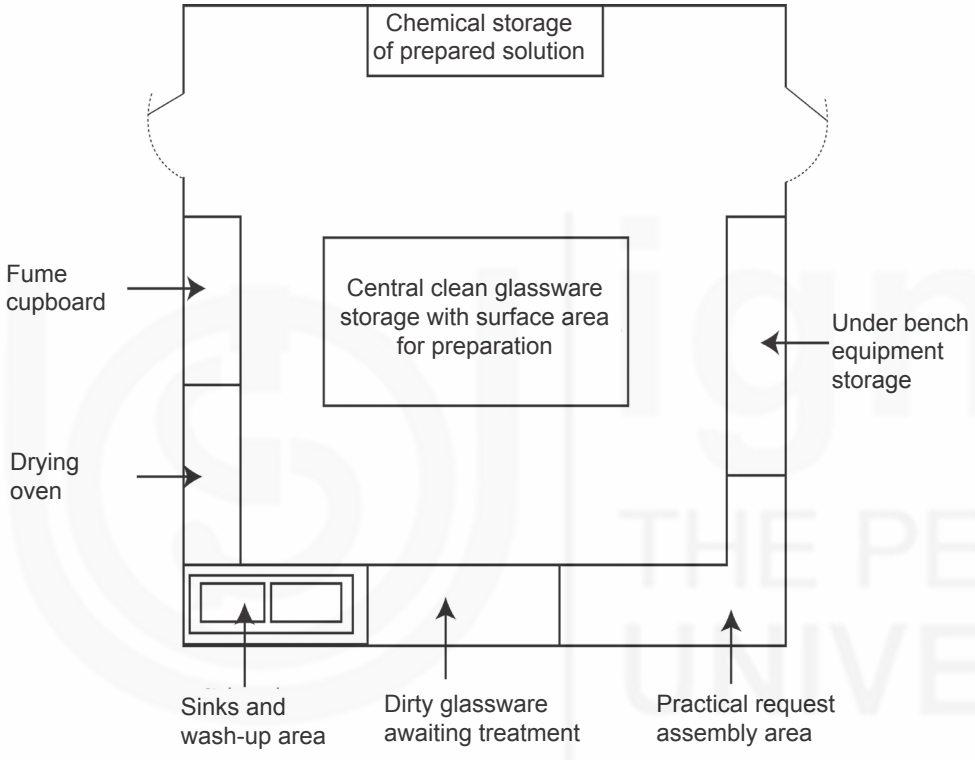


Fig. 3.3: A general plan of a standard preparation room.

Most preparation rooms should have:

i) Wet bench

ii) Dry bench

iii) Storage

iv) Work area

v) Proper Lighting and other Services

3.3.1 Wet Bench

The wet bench is a table which is provided with services for water, gas, electricity and waste disposal. A table of this type is generally placed against the wall of the room (Fig. 3.4).The following types of wet benches are essential for a preparation room:

i) A wet bench for washing glassware and biological material.

ii) A wet bench for preparation of reagents and stains.

iii) A wet bench for keeping a water distillation or deionizing plant. The water distillation plant can be wall mounted or placed on a stable bench, where to and fro traffic and disturbance is minimum. Both the distillation plant that is kept on the table as well as that which is wall mounted require electricity and water facility, close by or on the bench itself.

Fig. 3.4: A wet bench with a distillation plant.

In labs where accuracy in weighing is of prime importance and where zero-vibration is essential, a properly designed balance room may be built.

3.3.2 Dry Bench

A 'dry bench' would generally have a width of 600 mm and is either placed along a wall or could also be placed as an island unit. Refer again to Fig. 3.3. Do remember that dry benches need not be confined to the walls alone and so if necessary the floor space can be used, provided it does not interfere with general movement around the room. The following types of dry benches are essential for a preparation room for the following purposes:

i) A vibration free dry bench for placing the weighing balances (ideally a rough one and an accurate one) as you can see in Fig. 3.5.

ii) A large dry bench for dry work like constructing apparatus and for repair work.

iii) A dry bench for a vice (Refer Fig. 3.6) and small hand tools.

Fig. 3.5: A dry bench with coarse and fine balances.

The dry bench on which the weighing balance is placed should have a stable surface, where disturbance and to and fro traffic is minimum. The most commonly used balance is the modern electronic top pan balance since it is sufficiently accurate and can be used for many purposes. Modern electronic balances are so designed as to virtually eliminate the need for vibration-free benching. However, you should be aware that many laboratories still have balances with knife-edge systems for which reduction of vibration is essential. The manner in which anti-vibration (zero-vibration) base is constructed for these types of balances is however not going to be dealt with, in this unit as these types of balances are used in specialized research labs.

The dry work bench on which the vice (Fig. 3.6) is placed may also store hand tools.

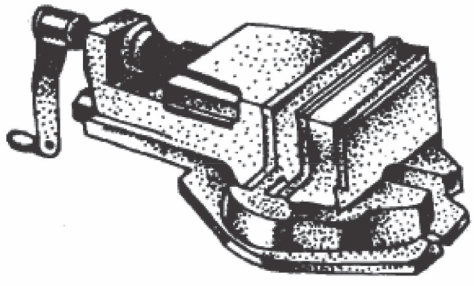


Fig. 3.6: A vice is a tool. It grips objects on which work is being done. Its grip is made tighter or looser by turning a lever at the same point. The lever is attached to a shaft which has a thread like bolt. For example the carpenter puts the pieces of wood in a vice so that it would not move around while he is planing (making it smooth and flat) it.

3.3.3 Work Area

An area for office work where the teacher or lab attendant could do paper work is also essential in the preparation room and requires a table for writing, a computer table with a computer and a printer and at least one filing cabinet to store a large quantity of paperwork (lab scripts, manufacturer's catalogues, work rotas (duties assigned), maintenance records, staff leave forms, stock control forms – the list can seem endless). A metal filing cabinet is generally used to store the paper work (Fig. 3.7).The material within the cabinet must be stored in a clear and logical manner so that anyone coming into the preparation room for the first time can understand the system.

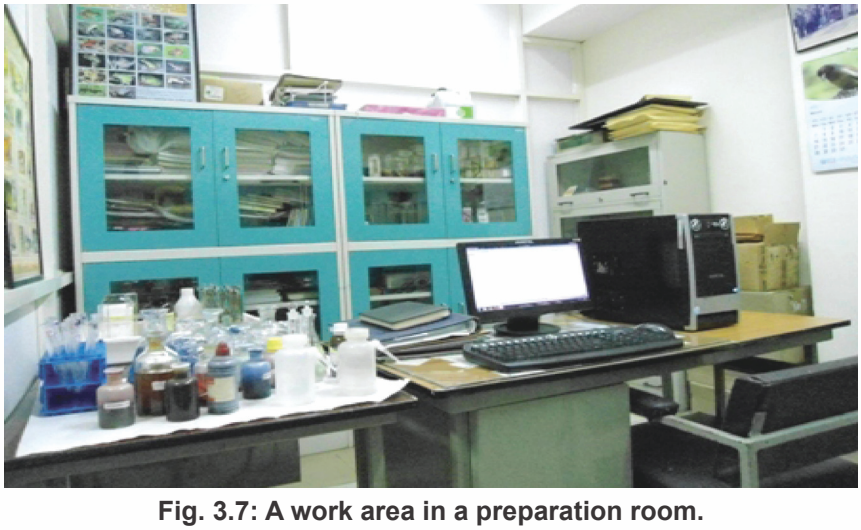


Fig. 3.7: A work area in a preparation room.

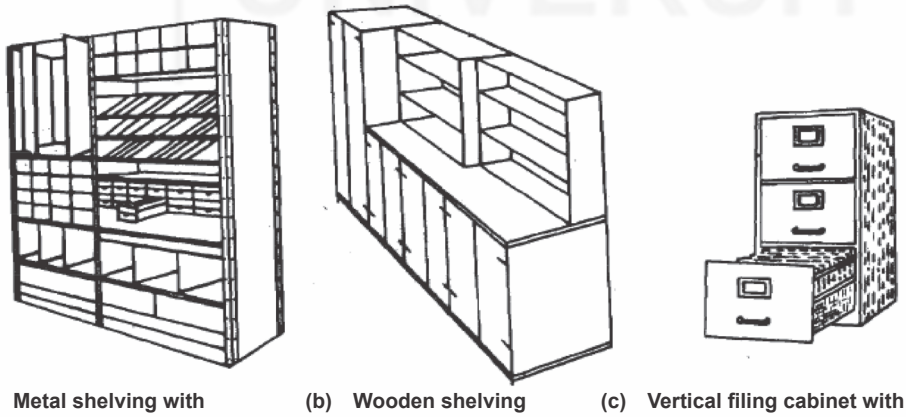
3.3.4 Storage

Many preparation rooms are used as store-rooms (Fig. 3.8) though ideally, a separate store should be provided for items that are only needed occasionally and for the storage of bulk consumables. However since, often a separate store is not provided, the preparation room has to store a diverse range of items in the storage units that are provided.

Fig. 3.8: A botany lab preparation room showing storage.

General Methods of Storage

An essential requirement of a preparation room is adequate shelving and cupboard facility for storage of apparatus, equipment and chemicals. Fig.3.9 shows some ideas for adjustable shelves based on a framework of angle-irons drilled with holes at intervals of every inch and fitted with adjustable shelves, bins and cupboards. However, for storage of materials wall cabinets mounted above the work table in the preparation room may prove useful.



(a) Metal shelving with angle iron frame (b) Wooden shelving and cupboards (c) Vertical filing cabinet with cabinet drawer showing folders

Fig. 3.9: Shelving and cupboard arrangements as well as a filing cabinet likely to be found in a preparation room.

Storage systems which have drawers or racks of varying depth and strength are most useful (Fig. 3.10). This allows segregation of ‘like’ materials together in sets or ranges which in turn allows quicker selection and distribution. When

selecting storage systems, great care should be exercised that safety factors are not overlooked. The major risk apart from the dangers involved with chemicals comes from heavy objects. Drawer and shelf constructions which do not adequately support heavy objects are of little use. Serious damage can and has occurred when a tray on a high shelf has broken from its supports and crashed down onto the trays below in a 'domino effect'.

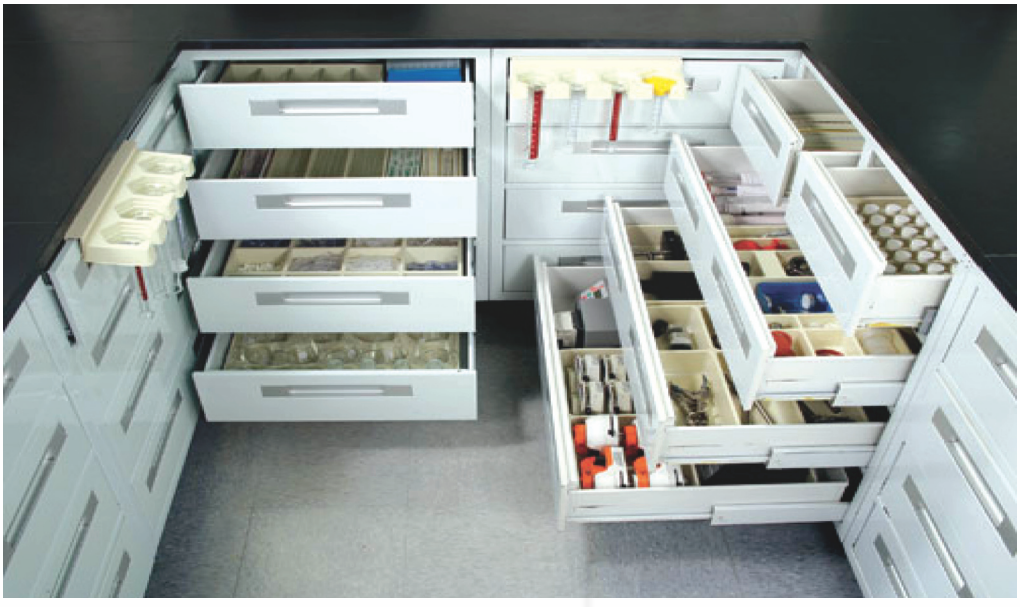


Fig. 3.10: Storage system with drawers of varying depth.

The items in the storage system should be arranged with some thought. The heaviest items should be stored at a height allowing easy removal and replacement. Do not be tempted to put the heaviest items on the floor or the lowest shelves since this can lead to a risk of back injury (see Fig. 3.11).

Fig. 3.11: Heavy objects should be placed at a convenient height to avoid back strains.

Small items such as lamps, corks, teats and bottle tops can be kept in trays with dividers (Refer to Fig. 3.10 again). Most commercial systems do provide this feature. If the storage system is often used, then open bins that are used in stores may be useful but do remember that these collect dust and dirt and therefore are not suitable for keeping things that are seldom used.

Storage of Equipment and Glassware

Storage of equipment and glassware in the preparation room is always a very difficult problem for there always seems more equipment in use than there are cupboards to keep them in. Their storage under the bench cupboards however, should be avoided as access to the equipments and glassware stored there is difficult with the result that they are often not used fruitfully at all. Extra glassware and equipments stored in the preparation room should be kept on adjustable metal shelves.

Storage of Chemicals

Chemicals stored in the preparation room should be kept on wooden shelves as wood resists chemical attack very well (see Fig.3.9 again). Nowadays cupboards that store chemicals are also provided with ventilation chimneys so that the corrosive fumes do not accumulate in the preparation room or store and get released outside. The safe storage of chemicals is a major problem and has been dealt in greater detail further in this course. However, here we shall examine the difficulties of storage of chemical containers. Preparation of chemical and biological solutions is one of the prime functions of the preparation room staff, so it is essential that the storage of these chemicals is designed to allow maximum availability to the technical staff and minimum availability to potential thieves.

1. ***Liquids***

Liquid chemicals are supplied in glass bottles and so while storing them you should bear this point in mind. Most glass Winchester bottles, i.e. those which hold two or two-and-a-half litres should be stored at a fairly low level slightly above the floor. Shelves provided with a raised lip in front are very useful as this prevents bottles overlapping the edge of a shelf and running the risk of being knocked off. Flammable solvents may be kept in cabinets which are designed to minimize the risk of fire spread, or preferably in a solvent store if presemt.

2. ***Containers of solid chemicals***

The largest of the laboratory chemical containers holds 3 kg. These should also be kept at a low level to avoid people stretching to reach the chemicals or from having to use steps to attain the right height to reach the required shelf.

3. ***Small bottles of chemicals and stains***

Bottles holding quantities of less than 25 g or ml present their own problems as far as storage is concerned. If they are kept with the routine sizes they will become hidden behind larger bottles and subsequently become ‘lost’. Drawer units with dividers are one way to overcome this problem. Chemicals in each division can be stored alphabetically to facilitate the search.

4. ***Refrigerated samples***

Samples requiring refrigeration either at 4°C or in a deep freeze condition can also be sub-divided. Polythene sandwich boxes are most useful here. They allow removal of a group of samples without letting the rest of the samples warm up.

5. ***Dispensed solutions***

The most difficult storage problems however is that of solutions which have been made up ready for use and are waiting in the preparation rooms or which are to be kept for future occasions. The best way of storing them is on a shelving system which is flexible and they should be put in standard size containers as these are easier to store than bottles of differing shapes and sizes.

Many other factors affect the choice of lighting systems such as colour of walls, height of ceilings, amount of light available and nature of work operations. Work involving the use of revolving machinery should always be carried out under tungsten bulbs and not fluorescent tubes for safety reasons since certain stroboscopic effects may be set up. Some spectroscopic systems are also sensitive to fluorescent lighting.

3.3.5 Proper Lighting and other Services

Proper lighting both in the preparation area and main laboratory is essential for safe and effective operations. Strip lights are most commonly found in these areas and their placing is important so that shadows are not thrown on the work space.

Various recommendations are given in technical journals as to the amount of light which should be available. Whilst engineers may measure the amount of light available with meters, the persons working in the area will soon know if the light is too dim or too bright by the frequency at which they experience distress whilst working. If you find that you and your colleagues are getting headaches or eye strain, complain immediately to your superiors to rectify matters or if you have the authority, get the lighting changed on your own initiative.

SAQ 2

a) List the basic components of a standard preparation room.

b) What is the main difference between a wet bench and a dry bench?

The range of services, like water, gas and electricity and efficient drainage and disposal system which are available in the lab (Refer to Unit 2 where services have been explained at length) are also essential for a preparation room. These services can be extended from the lab through the walls into the preparation room.

SAQ 3

A certain amount of storage will probably have to be provided in a preparation room. Is a conflict likely to occur between its use as a preparation room and as a store?

3.4 ACCESS TO THE PREPARATION ROOM

It is essential that access to the preparation room is restricted as the preparation room will contain expensive and dangerous materials and also costly equipment. Doors that lead from labs or the corridors to the preparation room are usually fitted with door closures in order to comply with fire regulation. Doors are often installed to prevent the spread of smoke in case of fire.

In order to further restrict access to the preparation room a locking system is also installed which can only be operated by authorized key holders.

SAQ 4

Why is it necessary to restrict access to preparation room?

3.5 WORK FLOW IN THE PREPARATION ROOM

The most important principle in the design of a preparation room is the aspect of the work "flow" through the area. For proper work flow the operation or function of the preparation room is examined and the components of such an operation are identified by procuring advance information about the planned experiments and demonstrations. Work plan for an experiment/demostration should be displayed in a place which is readily accessible for checking when starting the work. Clean glassware and chemicals will be required. When solutions have been prepared, stock bottles will be needed together with trolleys or trays for transporting them and also the equipment. The returning trolleys will have dirty glassware and leftover chemicals which require attention. An area will be required for glassware cleaning and finally this cleaned glassware will again be required to restart the laboratory exercise.

3.6 MICROBIOLOGICAL PREPARATION ROOM

The microbiological preparation room is very different from the usual preparation rooms since an important and most fundamental part of microbiological preparation room is sterilisation (of microbiological material, glassware and other apparatus), towards which such a room is clearly geared. Preparation rooms in large microbiology units may have a variety of sterilisation methods available. All materials have to be sterilised before and in some cases after use.

3.6.1 Access to Microbial Preparation Room for Bacteria and Fungi

Microbiological preparation rooms for bacteria and fungi have their own security problems. The culture of micro-organisms concentrates the cells to huge numbers compared with the numbers found under normal working circumstances. It is therefore, most important that cultures are kept in restricted areas. Most educational and industrial laboratories are unlikely to have highly dangerous organisms although some of the less 'dangerous' bacteria can also often give rise to unpleasant symptoms if contamination is in excess.

The best method to prevent spread of potentially infective material from the microbiological preparation rooms is to ensure that access to it is restricted to a few. It is essential that all staff that have access to the contaminated areas are vigilant and are aware of their responsibilities. When cultures are provided for examination they must be fixed prior to use.

3.6.2 Sterilizing Equipment

The standard sterilising apparatus that are used in the microbiological preparation rooms are autoclaves and hot air oven.

Autoclave

An autoclave is a large version of the domestic pressure cooker. It has controllable pressure and temperature facilities and may be used to sterilise media used for microbial culture, glassware, instruments, equipment and other items. It is also used to sterilise waste material before disposal. Normal operation conditions for autoclaves are 121°C at 15 p.s.i. for 20 minutes.

Autoclaves generate a large amount of heat and steam and often also an unpleasant smell when they are used, so they should be placed in a designated area of microbial preparation room which has a proper ventilation system that can cope with these problems. Proper ventilation can be provided by means of a simple extractor fan or by a highly sophisticated air treatment system. Furthermore the arrangement of sterilisation facilities should be organised in such a way so that the work area of the technicians in the microbiological preparation room does not adversely affect their health!

Hot Air Oven

Hot air ovens in addition to autoclaves, are also used for sterilisation. These are used for dry sterilization and work at temperatures of 160°C giving rise to the problem of additional heat in the room. Dry sterilisation methods are suitable for pipettes and other glassware not containing liquids.

SAQ 5

What is the main function of an autoclave?

3.6.3 Preparation Area

The preparation area in a microbiological preparation room should have a bench space for the assembly and treatment of the equipment and an area for the storage of sterilised materials. Storage of sterilised material is not normally a problem, provided that seals marked ‘sterile’ are used and that the materials are used strictly in order of production.

Pipette canisters which are box-shaped in cross section are most suitable for storage purposes as they can be stacked in drawers with little loss of available space. The round canisters are most likely to roll about and they produce waste space when stored together. Preparation room which contains autoclaves should be fitted with a floor drain and some form of non-slip finish to the surface (Fig.3.12). Using an autoclave invariably leads to spillage of water on the floor and so an efficient drainage system will minimise the risk of an accident.

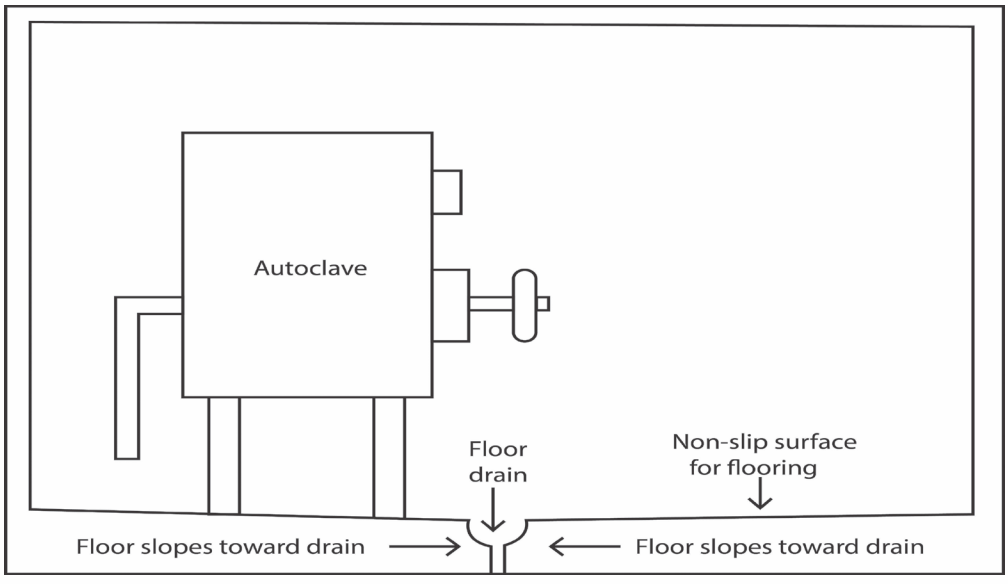


Fig. 3.12: A microbial preparation room with a autoclave.

SAQ 6

Which are the special precautions that have to be taken in rooms used for the preparation of bacterial and fungal cultures?

3.7 STORE AND THE FLOW OF MATERIALS

The volume of material that passes through a store and the nature of the material that has to be stored varies enormously from one lab to another. However, same basic principles apply both to the requirements of the storage place and to the flow of materials.

Before considering the design of stores, it is important that you appreciate the pattern in which materials flow through or between stores. In an ideal situation, three separate stores need to be provided, as shown diagrammatically in Fig. 3.13.

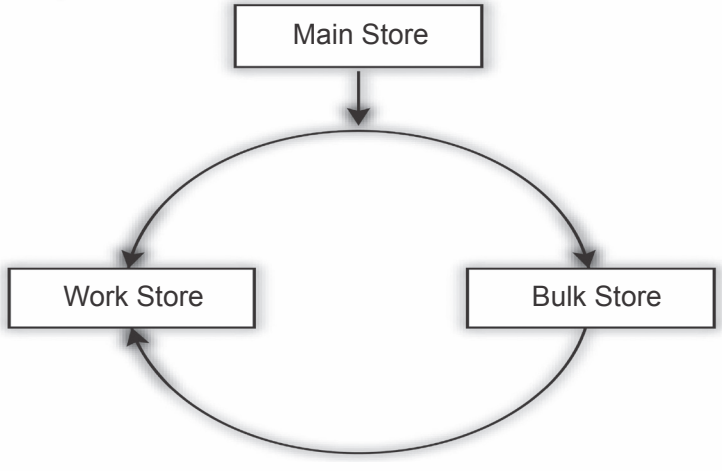


Fig. 3.13: The primary flow of materials.

Three physically separate stores may not be provided in small institutions, however the concept expressed in Fig. 3.13 can easily be implemented in a

single store by designating the three area in it as: (i) main store area (ii) bulk store area (iii) work store area. This concept is the way in which materials are moved before being distributed to the lab worker.

Let us now consider these three stores individually.

1. **Main store:** This is the area in which goods are received and checked. They are then either unpacked for immediate use, in which case they will be moved directly to the laboratory or to the work store; or they are repacked and moved to the bulk store.
2. **Bulk store:** As its name implies, this is the store, or the area within a single store, in which materials are held for some time. Typically, unopened cases of glassware or chemicals are stored here for future use.
3. **Work store:** From this store materials will be drawn for day-to-day use, e.g., working solutions for chemistry work.

3.8 ARRANGEMENT OF STORES

The present section deals with the basic principles involved in the design of stores. The design of stores as you will study in this section, are based on the kind of materials that have to be stored. In this section our focus will be on principles involved in the design rather than on constructional diagrams of stores. Once you become aware about the basic principles that should be considered while designing a store you would be able to apply these principles to new or old stores under your supervision.

3.8.1 Environmental Considerations

Two important points that we should bear in mind while designing a store are that:

1. Many items will deteriorate if stored under wrong conditions, such as extremes of temperature and dampness.
2. Hazards to health must be prevented and so proper safety features should be installed and adopted. Dangerous materials should ideally be stored away from the main building in a special store.

It should be kept in mind that though the location of the store, within the structure of the main building as well as its physical dimensions, are important, however, the most important aspect of the store is its environment which is determined by the four main factors:

1. Ventilation
2. Humidity
3. Temperature
4. Lighting.

Ventilation is required to maintain the clean air inside the store and to prevent humidity and dampness which would adversely affect the material stored in the store. The ventilation in the store should be adequate enough to control the temperature in the store and so should be such that it provides sufficient warmth in winter, and keeps the store cool in summer. In case the natural ventilation is inadequate, some form of air conditioning will be required. Another environmental factor that is often ill-considered is lighting. A store

should be well lit so that the materials stored are clearly visible and any damage to the stored material is immediately detected and rectified.

Having considered environmental requirements, we'll now think about physical considerations.

3.8.2 Physical Considerations

The main physical aspects that we should consider within the store for storage are:

1. The shelving arrangements on which the stored materials have to be kept,
2. Access or circulation space where one can safely reach the materials required,
3. The location of the store in relation to the outside world. For instance if heavy goods are stored in the store then direct, outside access will be required, and
4. Entry of the store – independent entry or from the laboratory itself.

1. Shelving

In storage the strength of the shelves is extremely important factor. Nowadays several types of shelving -wooden, metal, plastic-coated metal etc. are available and all have their specific uses .You would need to decide which would be most suitable for the kind of material you plan to store. In case of a chemical store, for example the material of the shelves should be inert in which case your choice for shelves would probably lead you to choose wooden shelves. In practice, the stores of most establishments will require a range of different types of units – shelving units, cupboards, racks and tray units.

Activity 1

1. Make a list of the types of shelving present in your store and laboratory.
2. Look at the suppliers' catalogues and advertisements to see which kinds of shelving systems are available in the market and then list here what you would like to use in your work place.

From Activity 1, you should appreciate another aspect of the design of the store: that a store must be designed and fitted out to meet the requirements of the particular laboratories with which it is associated.

2. Layout of Store

The layout of a store can be planned and arranged in several ways. However the best layout or arrangement for your store would be the one that meets your requirements. In nearly all teaching and research establishments the space provided for a store is usually inadequate. However, despite this constraint you should design and orgainse your store in such a manner that it allows easy access and at the same time provides adequate or maximum storage. In Fig. 3.14 you can see the plan of a fairly traditional layout of a store with a regular array of shelving units.

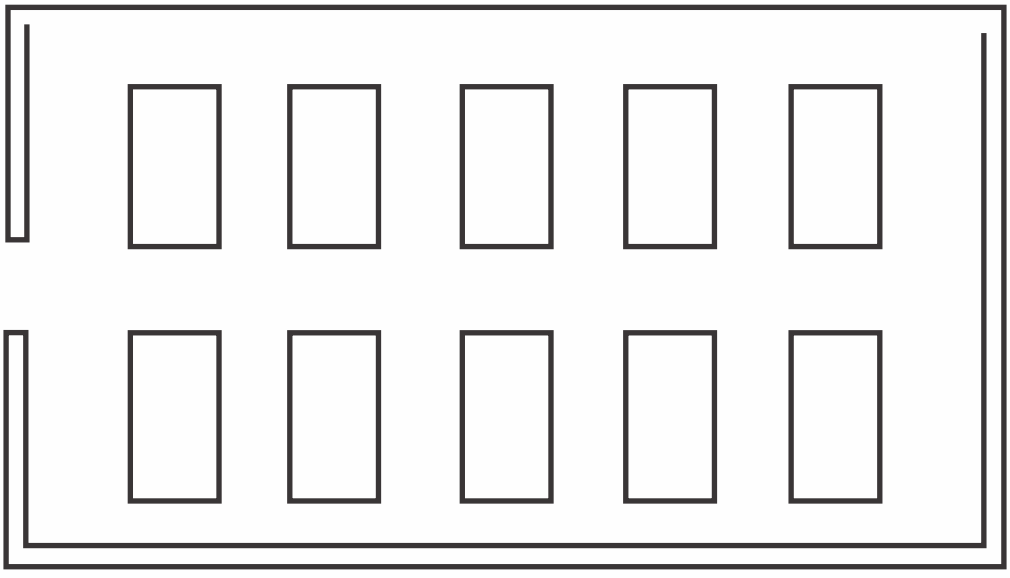


Fig. 3.14: A traditional layout of a store with a simple array of shelving units.

Looking at this layout, it must be obvious to you that a considerable amount of space has been used and wasted in order to ensure easy access to the stored material. This store space could have been better utilized by having mobile storage units on wheels (Fig. 3.15).

Fig. 3.15: A store showing proper shelving and mobile storage.

The mobile units could then be rolled and kept together most of the time. However, when necessary or when access is required these units could be moved apart. You should keep in mind that the space required for access is not just for staff to walk between units but may also be needed for trolleys. Fig. 3.16 shows an ideal arrangement within a store in which most of the requirements that we have discussed so far have been adopted.

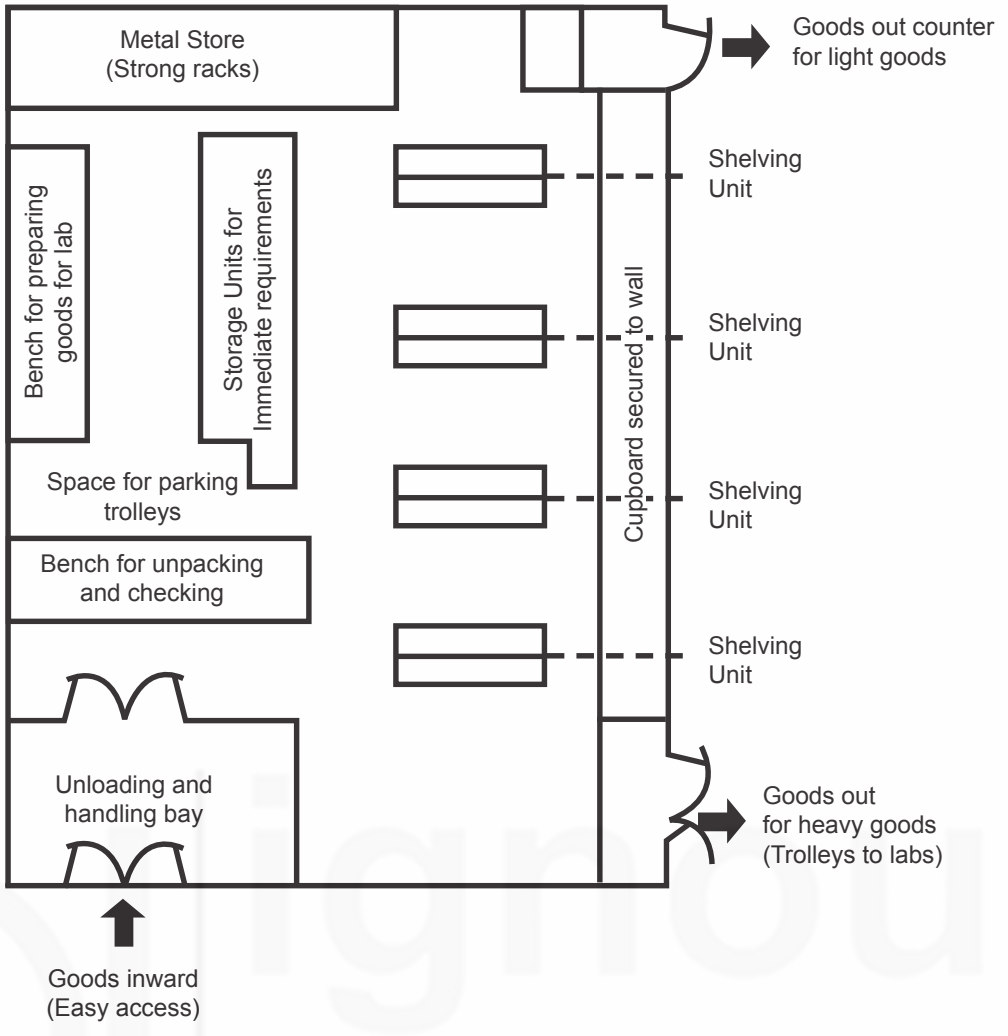


Fig. 3.16: A design for an ideal store.

3.9 FLEXIBILITY OF STORE DESIGN

Before proceeding further, you should appreciate two factors which were not specifically indentified and which certainly cannot be ignored:

1. For a given space to be used as a store, more than one design could meet the requirements of the user. Each design will have its own merits or faults and each will have to be justified on its merits.
2. As factors change with different patterns of usage, the demand on the store will change. It is important that changes can be accommodated with the minimum of inconvenience. There is only one way in which this can be achieved, and that is to incorporate as much flexibility as possible.

Flexibility can be enhanced in many ways at little or no extra cost. Some examples are as follows:

1. Where possible, use free-standing storage units.
2. Use units which allow for easy repositioning of shelves, or use units where shelves can be replaced by trays or bins.

3. Avoid fixing units to walls and floors.

Now try the following SAQs.

SAQ 7

Write down three questions that need to be asked when designing a store.

i) ……

ii) ……

iii) ……

SAQ 8

Do you think that a single arrangement or design can be expected to meet all storage requirements? Justify your answer.

☐ Yes ☐ No

Reasons:

SAQ 9

a) 'It is necessary to control the environment within a store'.

Briefly comment on this statement and explain which particular factors are likely to require control.

b) Imagine that you are arranging a store and wish to achieve a reasonable level of flexibility. List three features which you would incorporate to achieve the required flexibility.

3.10 SAFETY PROVISIONS

In addition to the design of the store, several other factors relating to safety must be considered if you are involved in commissioning a new store or are using an existing store. These factors are as follows:

1. **Fire-fighting equipment:** This should be housed outside the store.
2. **Smoking:** NO SMOKING signs must be prominently displayed.
3. **Type of Furnishings:** The materials used in the store for shelves, etc. must be non-combustible.

4. **Access:** Only authorized staff should be allowed to have access to the store.
5. **Transferring liquids:** Liquids must not be poured from one container to another in the store. This activity should be performed elsewhere.
6. **Alcohol:** A locked cupboard must be provided for stored alcohol. This cupboard should only be used for this purpose. (A lockable cage would suffice and also provide ventilation.)
7. **Regulations and legislations:** It is more or less certain that one or more sets or regulations enacted under an Act of Parliament may apply to your store. Advice must be sought from competent authority/ safety officer in case of the following reasons:
   i) Regarding any regulations that may apply to the materials that may be stored;
   ii) If you take over responsibility for such a store; or if the function of the store changes.

Activity 2

List the regulations relating to safety that apply to your establishment. These could be general or specific.

3.11 LABELS: A CAUTIONARY NOTE

Bottles of chemicals stored in a store (where they might remain for some time) will eventually lose their labels. In practice, this can happen in quite a short time. This can be prevented by **painting over the label and for about one centimeter around it with molten paraffin wax**. This is a quick and simple process and can save much time. **Remember, do not do this inside the store itself but do it elsewhere** so that there is no danger of explosion in the store.

3.12 RECOMMENDED STORAGE AND DISPOSAL PROCEDURES

Some authorities and institutions provide a metal chest to store solvents, with the intention of allowing dangerous solvents to be stored within a main building. Our recommendation is that you do not store solvents in this way.

WARNING: METAL CHEST SOLVENT STORES ARE POTENTIALLY DANGEROUS DUE TO LACK OF VENTILATION WITHIN THE CHEST WHICH CAN CAUSE THE CONCENTRATION OF EXPLOSIVE MIXTURES OF FUMES.

The recommended procedures for storing items in the store are given in Appendix A. Appendix B gives the recommended procedure for disposal of materials kept in the store.

3.13 SUMMARY

In this unit you have learnt that:

- Preparation rooms and stores should be an essential feature of the main lab of educational/ (School/College/University/Research), industrial or private institutions.
- The preparation rooms are usually close or adjacent to the main labs to which they provide service.
- The main role of the preparation room is to store (but not in such bulk as in a store) extra glassware chemicals, reagents and a range of equipment which are not in continuous use and also to provide an area for preparation of solutions and reagents and for administrative paper work associated with the lab and preparation room.
- In most preparation rooms, specially those associated with educational labs, some preparation work like preparing solutions, and cleaning glassware is done prior to the experiment or demonstration to be conducted in the main lab.
- A standard preparation room should have (i) a wet bench (ii) a dry bench (iii) water distillation plant (iv) balances (v) adequate storage systems for chemicals, stains and paper work, (vi) vice and small tools, (vii) adequate water, gas supply and light; and should be provided. Electrical outlets should also be provided (viii) area for preparation work and (ix) office area for paper work.
- Access to the preparation room needs to be limited due to the dangerous and/or expensive chemicals and equipment housed there.
- Preparation rooms are planned and built in accordance to the laboratories they serve and so provision for lighting, storage as well as for services like gas, electricity and water is made according to the need of the labs.
- Microbiological preparation rooms contain special sterilising apparatus like autoclaves and/or hot air ovens since an important function of such rooms is sterilisation. This is because microbiological studies require all materials to be sterilised before and in some case after use.
- The use of autoclaves and hot air ovens create environmental problems in the preparation room and so these rooms are planned in such a way that these problems are overcome.
- Goods and materials required by the laboratories flow through or between stores. In ideal situation three separate stores i.e., **main store, bulk store** and **work store** are required to store the material but in most school and colleges there is only one store and so three specific areas can be designated in the single store - **main store area, bulk store area** and **work store** area.
- While deigning and arranging the layout of a store, the environmental and physical factors should be considered.

- Store should be designed according to the needs of the laboratories and so their design should be flexible.
- Safety provisions such as firefighting equipment is essential and should be available and located just outside the store.
- Bottles in a store should be properly labelled and solvents should not be stored in metal chests.

3.14 TERMINAL QUESTIONS

1. Describe the basic requirements of a preparation room.
2. Describe how various kinds of chemicals could be stored in the preparation room for easy availability.
3. How does the operation of autoclaves adversely affect the preparation room? How can this be rectified?
4. Which important environmental factors should be taken into consideration while arranging a store?
5. How can the labels on chemical bottles be kept for a longer time?

3.15 ANSWERS

Self-Assessment Questions

1. The function of a preparation room is to provide service to the main labs. This involves storage of a range of equipment and apparatus which are not in continuous use as well as storage of extra quantities of chemicals and reagents. In addition to this administration work associated with labs are done here. Also much of the prior preparation of experiments and demonstration is conducted here.
2. a) The basic components of a standard preparation room are:
   i) A wet bench
   ii) A water distillation plant
   iii) A dry bench
   iv) Balance (an accurate one and a rough one)
   v) Vice and small hand tools
   vi) Adequate shelving and cupboards
   vii) An area for office work
   viii) Adequate electrical outlet sockets and gas supply
   ix) An efficient waste disposal system

   b) The basic difference between a wet and a dry bench is that the wet bench has water connection with sink, draining board etc. while the dry bench does not.
3. Yes, however in most cases little can be done, except for finding alternative accommodation.

4. It is necessary to restrict access to the preparation room because it is likely to contain expensive and dangerous equipment.
5. Autoclaves are used for sterilisation of a wide range of culture media and equipment.
6. i) Cultures should be kept in special areas.
   ii) Access to these areas should be restricted.
   iii) All materials should be sterilized before and generally after use.
7. i) What are the specific requirements of the organization?
   ii) What environmental problems are there?
   iii) Are there any safety implications?
8. No. No one design can be expected to meet all requirements within one establishment. The problems then multiply when considering the requirements of various institutions.
9. a) Control of the environment is most important. Lack of control can have serious safety implications which could in the worst case lead to an explosion. Also many stored materials may deteriorate unless stored under appropriate conditions. Particular factors requiring control are temperature, humidity, ventilation and lighting.
   b) i) Where possible, use free-standing storage units.
      ii) Use units which allow for easy repositioning of shelves, or use units where shelves can be replaced by trays or bins.
      iii) Avoid fixing units to floors and walls.

Terminal Questions

1. Refer to Section 3.3.
2. Refer to Subsection 3.3.4.
3. The autoclave when used, generates a large amount of heat, steam and often unpleasant smell. These problems can be minimized at the planning stage of the microbiological preparation room by installing adequate ventilation systems which can cope with these problems. At a smaller scale a simple extractor fan will be adequate. However in bigger preparation rooms the installation of highly sophisticated air treatment system is better.
4. a) Ventilation
   b) Humidity
   c) Temperature
   d) Lighting.
5. Labels on bottles of chemicals can be kept for a longer time by painting over the label and for about one centimeter around it with molten paraffin wax.

APPENDIX A RECOMMENDED STORAGE PROCEDURES

Sl. No.	Item	Recommended Storage Procedure	Comments
1.	Perishable	Cold store	To reduce rate of decay.
2.	Gas cylinders	Vertically-chained up or in horizontally specially designed racks	Must not be stored overnight in the laboratory. Should be kept outside the main building. Could be stored in a solvent/ chemical store, as this is well ventilated. Check present legislative requirements.
3.	Chemicals	Inorganic – alphabetical order Organic – molecular formula. Store in well ventilated area.	Make sure that chemicals that react together are not stored alongside each other. Treat all chemicals as potentially hazardous. Check current legislative requirements.
4.	Poisons	Secured place – Locked cupboard	Antidotes must be available. Check current legislative requirement.
5.	Animal foodstuffs	Dry, cool place.	Make sure stock does not deteriorate.
6.	Glassware	Re-pack into boxes as supplies	Avoid breakages.
7.	Delicate equipment	Re-pack into boxes as supplies	Avoid breakages.
8.	Metal stock/ wood	On suitable racking	Store away from moisture
9.	Museum materials	In Perspex, in formalin jars or embalmed.	Formalin in jar should be replenished from time to time. Museum specimens should be kept clean in order to prevent pests.
10.	Herbarium	Dry cool conditions	Reduces deterioration of samples.
11.	Radioactive sources (rarely found in school or colleges).	Stored under ‘lock and key’ preferable in safe.	Log book of all movements must be kept. Check current legislative requirements.

APPENDIX B DISPOSAL PROCEDURE OF STORED MATERIALS

Sl. No.	ITEM	RECOMMENDED DISPOSAL PROCEDURE	COMMENTS
1.	Chemical	Each chemical needs to be considered separately: I) **Flammable liquids:** Consult teacher in charge II) **Water miscible:** Dilute with copious quantities of water or allow to evaporate. III) **Water immiscible:** Mix with surfactants. Dispose with plenty of water or mix with sand or allow to evaporate. IV) **Acids:** Dispose with copious quantities of water. V) **Compounds that react with water:** unless you are skilled at disposing of this class of material, you should not attempt it. **No instruction given here on purpose. Seek advice.**	Seek advice when necessary from the teacher in charge of the lab. Consult specific publications on safety, and current legislative requirements.
2.	Biological	Disposal of animals remains and microbial materials by incineration or burial or disposal company. Microbial cultures have to be sterilized prior to disposal	
3.	Animal House	All waste to be sterilized before disposal except for animal remains whose disposal is given above in point 2.	

UNIT 4

DAY-TO-DAY MANAGEMENT OF THE LABORATORIES

Structure

4.1 Introduction

Expected Learning Outcomes

4.2 Organisation of Practical Work/ Demonstrations

Day-to-day Organisation

Day-to-day Cleaning up

Sterilization

Disposal of Wastes

4.3 Routine Inspection and Maintenance of Laboratory

4.4 Maintenance of Equipment, Apparatus and Furniture

Prevention of Dust

Reduction of Vibration

Prevention of Corrosion and Rust

Protection of Equipment from Excessive Heating

Correct Usage of Instruction Manuals

Servicing of Equipment

Servicing of Furniture

4.5 Cleaning of Laboratories and Preparation Rooms

4.6 Colour Coding of Services

4.7 Emergencies with Services

Emergency Procedure

Flooding

Gas Leaks

4.8 Security and Vandalism

Security of Premises and Immediate Working Area

Protection from Vandalism

4.9 Summary

4.10 Terminal Questions

4.11 Answers

4.1 INTRODUCTION

In the previous Units 2 and 3, you have learnt about the basic principles of laboratory, preparation room and store designs. You have also learnt about their functions. The laboratory is meant for conducting experiments and demonstrations while the preparation room, as the name suggests, is used for pre-experimental and pre-demonstration preparation. The store is used for storage of extra material. In this unit we will study how day to day management of the preparation room and laboratory can be carried out in an efficient manner.

Effective organisation of the laboratory and preparation room is essential for efficient service to be provided. The factors involved for doing this are: planning

for experiments and lecture cum demonstrations sessions; ordering of supplies and maintenance of stock control (Refer Unit 5 – Stock Control and Purchase in Block 2). None of these need to be particularly difficult if tackled properly.

Human management is also an aspect of running laboratories which however is beyond the scope of this unit.

Expected Learning Outcomes

After going through this unit, you should be able to:

- ❖ explain the essential aspects concerning organisation of practical work and demonstrations;
- ❖ explain the procedure for proper maintenance of laboratories and their preparation rooms;
- ❖ describe the method for organising the laboratory work;
- ❖ describe the necessity and problems of providing for cleaning laboratories and preparation rooms, etc.;
- ❖ describe how to clean laboratories and preparation rooms;
- ❖ describe the colour codes for various laboratory services;
- ❖ list out the correct procedures to be carried out in the event of emergency situations with respect to laboratory services;
- ❖ explain the need for security of both premises and the immediate work area (i.e. the laboratory and preparation rooms); and
- ❖ explain the problem of vandalism and state the measures that can be taken to prevent its occurrence and its effects.

4.2 ORGANISATION OF PRACTICAL WORK/ DEMONSTRATIONS

In order to run a lab efficiently, good planning is essential. The planning of practical work given in this unit is concerned only with the teaching labs. The requirements in industry and research laboratories tend to be different.

In a teaching lab most lab work involves preparation of solutions or arranging equipment or specimens for practical classes and lecture cum demonstration sessions. Neither of these tasks can be done in a hurry. It is not advisable to start a practical or demonstration session without

- proper planning
- essential solutions or equipment or samples, and
- correct choice of materials or concentration of solutions etc.

For lab work to be carried out efficiently and satisfactorily it is essential that there is good cooperation between the laboratory staff and academic staff. This is because prior information about the demonstration/experiments to be conducted is necessary for the planning and preparation of the experiment. For the proper conduct of the experiment the academic staff should usually ensure that:

1. a reasonable amount of time is given for pre-laboratory preparation,
2. full details of what is required are given to lab staff,
3. details of any special requirements are also given, preferably in consultation with the concerned lab technician/assistant, especially if special pieces of material or equipment are needed.

4.2.1 Day-to-Day Organization

For good organisation, the day-to-day requirements for the practical classes are usually entered into a diary/register/note book, kept solely for that purpose, and the academic staff would give advance (at least two days) notice to the lab technician/assistant for the preparation of the practical. You should therefore expect the academic or the teaching staff to enter into the diary the following details at least two days before it is required:

1. Number of students, time of class and room number
2. List of equipment required
3. List of solutions required to be prepared
4. List of chemicals, solutions, stains and/or biological material required, and
5. Note by academic staff for any special requirements or hazards.

The routine is quite simple – Each day check the diary for the requirements, not only for that day but also for the next two days. Also find out if there is anything to be prepared at the last moment or anything that may take a long time to prepare. Ensure that the preparation for all the experiments for that particular day and the next day is complete.

Decide what solutions have to be prepared during the course of the day, and be sure that you know the correct concentration and volume to make up. It is a good idea to keep a stock solution of 5-10 litres of certain solutions (e.g. 2 M sodium hydroxide, hydrochloric acid, sulphuric acid, nitric acid and ammonia solutions) that are commonly used to prepare lab reagents.

Ensure that the volume of the required solution is adequate. For example, allow only about 100 ml of solution for titration to each student and only10-20 ml per student for a simple ‘test-tube’ test. This prevents waste and does not allow students to get into wasteful habits.

Once the solutions are prepared, they should be put into bottles of the correct size and labelled with the date, name and concentration of the solution. For this purpose always keep a stock of clean bottles especially Winchester bottles.

The same sort of routine can be used to the provision of procuring of animals/ plants materials and preparing culture medium in order to make sure that there is sufficient quantity of the correct material for class use.

Also assemble whatever other equipment is required. If all the apparatus for the practical is placed on a trolley or tray then it can be moved to the lab from the preparation room with minimum difficulty.

Lecture demonstrations of the experiments have to be set up prior to the experiment so that everything is at hand when it is required. It is very important

that demonstrations proceed smoothly; therefore all the apparatus should be checked before the experiments to ensure that they are in proper working condition. Physics practicals may present a different problem in that the same equipment may be required a number of times. In order to avoid unnecessary work, it is suggested that materials for a particular experiment be assembled and kept in plastic trays. These trays may fit conveniently into cupboards specially designed to hold them.

4.2.2 Day-to-Day Cleaning Up

When a practical is finished remove all equipment and chemicals and ensure that the lab is clean and tidy. DO NOT keep small volumes of solutions in the hope that they might come in handy; **DISCARD THEM SAFELY**. Ensure that all equipment and apparatus are clean before putting them away: this particularly applies to pipettes and burettes, which must be thoroughly cleaned after use. Pipettes are best cleaned by placing them in a 2 litre measuring cylinder filled with a detergent, or chromic acid and then rinsing them with lots of water.

WARNING: CHROMIC ACID IS CORROSIVE

SAQ 1

Why should the technician have advance information about the practicals to be conducted?

4.2.3 Sterilization

It is essential that instruments, culture media, and glassware be sterilised for experiments involving micro-organisms and cell and tissue culture, etc.

Sterilization as we have explained in Unit 3 of this course is most efficiently and conveniently carried out in an autoclave or, failing that, in a pressure cooker. For most purposes, sterilization is sufficient at 121^{o}C temprature at 15 p.s.i for 20 minutes.

Instruments, pipettes, syringes, etc., should be wrapped in paper or metal foil before being autoclaved and should be kept wrapped until required. Test tubes should be plugged with cotton wool before hand and the caps of screw-topped bottles should be loose.

The sterilized material is unsealed just prior to use. After unsealing they, are again quickly re-sterilised by heating in the flame of a bunsen burner or spirit lamp or gas flame, or by dipping in 50-70 per cent ethanol (ethyl alcohol).

Bench tops should be washed with an antiseptic, e.g. 3 per cent solution of lysol, before the experiments are started.

For sterilization of skin, swab the skin with cotton wool soaked in 70 per cent ethanol. Alternatively use a pre-packaged medical swab obtainable from suppliers.

4.2.4 Disposal of Wastes

The disposal of wastes presents a real problem in a large laboratory with many students. Wastes should be disposed off promptly and not allowed to accumulate. Nowadays, institutions often have contracts with disposal company to ensure safe waste disposal. Many institutions have specific regulations regarding disposal of wastes, and these should be followed. If however, no such regulations exist, the following suggestions may be helpful:

Acids and bases may usually be discarded in the sink with a large quantity of water. If a concentrated solution is involved, pour this into a large volume of water and then discard the diluted solution with a good flow of water.

Alcohols of 70 per cent or more, which are not contaminated with xylol, toluol, etc. should be saved in a separate container for use in alcohol/spirit lamps.

Alcohols below 70 per cent, and those which are contaminated with other reagents may be discarded in the sink along with a good flow of water.

Cultures must be sterilized before disposal.

Biological Material

Animal tissue or any other biological material must also be safely disposed. Animal remains should always be placed in a separate container. The only completely safe way to dispose of biological material is to incinerate it, but if this is not possible, care must be taken to sterilize the material properly in case of microbiological material before disposing it. In case of animal remains you need to dispose them off by putting them in a black plastic bag and burying the bag in the ground. Simply placing the material in a plastic bag and putting it in the dustbin is NOT good enough. Go through Unit 10 of Block 3 of this course to learn more about disposal of biological and chemical wastes.

The two day routine suggested here is not the only appropriate system. Each establishment should and usually does devise a system to suit its particular needs. A period of one week may be convenient as it is relatively easy for academic staff to know what they will be doing in a week time and help you to prepare in advance, especially if you have to order for live biological materials from the dealer.

In all efficiently run labs, the academic staff does plan the practical work and gives instructions to laboratory staff well in advance. This enables the lab staff to function efficiently.

4.3 ROUTINE INSPECTION AND MAINTENANCE OF LABORATORY

A regular schedule of maintenance will help ensure that the lab runs efficiently. In order to ensure that regular checks are made it is a good idea to compile a series of check-lists detailing the things that must be checked on a daily, weekly or monthly basis. In this way one can be sure that checks are made and nothing is left to memory. Some things have to be done more frequently than others as is indicated below. (This is not an exhaustive list, merely a catalogue of the more important points:)

1. ***Daily*** **:** Ensure that the labs are clean and tidy.
2. ***Daily*** **:** Ensure that the sinks are cleaned properly, that the drains are not blocked and that the grill over the waste water pipe is clean and in place.
3. ***Weekly*** **:** Clean the fume cupboards since they rapidly become a repository of dirty apparatus and bottles of harmful chemicals. Every week make sure that all unwanted equipment and apparatus are removed from the fume are cupboard. Clean the bench and ensure that the sink is free of obstructions
4. ***Monthly*** **:** Every month clean the chemical stains in the sink. Check to see that there are no leaks in the sinks or drains.

WARNING: ELECTRICAL FAULTS CAN BE FATAL AND MUST BE RECTIFIED IMMEDIATELY. THE DATA PUBLISHED BY DELHI FIRE SERVICE IN ITS ANNUAL REPORTS INDICATE THAT ELECTRICAL SHORT-CIRCUITS ACCOUNTED FOR 70% AND 69% OF FIRE ACCIDENTS IN DELHI IN 1995-96 AND 1996-97, RESPECTIVELY.

5. ***Monthly*** **:** Every month cleaning of fume cupboard windows on the inside is essential. Check also that the exhaust fan works properly and removes air rather than just stirring it up. Check also that the front door of the fume cupboard opens and closes easily.
6. ***Monthly*** **:** Every month check lab services like the supply of water, gas and electricity to labs since these are essential. Ensure that all water and gas taps are easy to operate i.e. can be turned on and off without undue effort, and that the outlets are not blocked. Inspect electrical fittings to make sure they are not corroded or burnt in any way. If they show signs of being burnt or corroded, have them replaced. A burnt socket indicates that the point has been overloaded, so check that the equipment connected to that socket is correctly fused and is in good working order. Keep a constant check on all electrical apparatus to ensure that they are attached to the correct fuse and, are in good condition and the connecting wires are not damaged.
7. ***Annual*** **:** White-washing of walls, painting and varnishing of furniture and recoating of table tops need to be taken care of, once a year or once every two years. This will maintain and enhance the looks of the laboratory (also refer subsection 4.4.7).
8. ***Maintenance of register*** **:** If you find defects in wiring, faulty equipment etc. it is essential that they are reported so that they can be rectified; therefore a suitable system of reporting faults is usually devised. It is suggested that a maintenance register is used for this purpose and that it is signed by the lab incharge whenever a complaint is entered. In this way, no-one can deny responsibility when something goes wrong.

SAQ 2

'The efficiency of a lab can be adversely affected by poor maintenance of services and equipment.' Discuss.

4.4 MAINTENANCE OF EQUIPMENT, APPARATUS AND FURNITURE

The amount of servicing and repair of equipment which can be undertaken by a laboratory technician in a school/college is limited. However, to ensure satisfactory performance of the various equipment, attention should be given to the type of environment and the manner of use the equipment is subjected to. Protection from dust, vibrations, corrosion and excessive heat will enhance the maintenance of the equipment. Use of instruction manuals in the operation of equipment helps reduce tear and wear as well as damage to equipment.

4.4.1 Prevention of Dust

Routine cleaning and dusting of equipment removes a lot of the visible dust. The effectiveness of the process depends on the amount of dust and the rate of accumulation of dust. Certain environments are likely to encourage rapid accumulation of dust on equipment. Long, dry periods cause the winds to carry a lot of dust from the neighbouring countryside. This calls for the following measures:

i) Installation of dust barriers on windows in the form of fine wire mesh or installation of air conditioner if affordable

ii) Keeping the doors closed most of time.

iii) Covering equipment with dust covers when not in use.

In case, where the surroundings of the laboratory and path from the laboratory to the compound are not covered (paved, grass), a lot of mud is brought into the labs during the rainy periods, which after a while dries up forming dust. The measures to reduce such dust should include:

i) Provision of dust or door mats at the entrances

ii) Mopping the floors several times in a day instead of dry broom sweeping

4.4.2 Reduction of Vibration

Constant vibration no matter how minor causes undesirable loosening and movement of various component of equipment which results in loss of alignment, precision and accuracy. The common sources of vibrations are:

i) Moving equipment when needed from place to place without care or without the use of trolleys

ii) Hammering on walls, benches and floors

iii) Banging doors, and windows

iv) Heavy traffic close to the lab

v) Loud noises

The measures to reduce vibrations should include:

i) Moving equipment when needed from place to place on trolleys

ii) Avoid hammering on walls, benches and floors

iii) Installing door and window catchers

iv) Covering the floor of the area close to the lab with linoleum or any other type of floor covering that dulls sound and reduces vibrations

SAQ 3

Why should constant vibration be prevented in a laboratory?

4.4.3 Prevention of Corrosion and Rust

Majority of the lab equipment are constructed of metals and plastics that would be affected and corroded by fumes and spillages of mineral acids and certain organic solvents.

The laboratory should have an efficient ventilation system and those experiments likely to produce fumes should be carried out in the fume cupboard. Equipment should be wiped after use in order to remove any droplets of liquid and chemical material. Furthermore, covering equipment or storing them in cupboards reduces chances of corrosion due to spillage.

4.4.4 Protection of Equipment from Excessive Heating

Equipment which are not meant for heating would be adversely affected by high temperature. Certain plastic or rubber components would harden and crack due to heat. It is therefore advisable to ensure that electrically operated equipments are switched off after use. Also heating operations or equipment should not be kept too close to other equipment and should be placed in the lab area which does not receive direct sunlight.

4.4.5 Correct Usage of Instructional Manuals

Laboratory equipment should always be operated in the manner recommended by the manufacturers. The technician should ensure that a copy of instruction manual is available to the users who may be students, research scholars or academic staff. Sometimes a list of operational steps could be copied from the manual and can be hung or stuck on the equipment to assist the users. The originals of instruction manuals should be filed under the custody of the lab in-charge. They may contain useful information for guarantee, servicing and repair.

4.4.6 Servicing of Equipment

Some servicing of laboratory equipment is simple enough to be undertaken by the lab technician. This includes:

i) Internal cleaning by use of certain solvents, blow brushes, vacuum compressed air,

ii) Lubrication,

iii) Replacement of bulbs, belts, nuts, bolts and screws and

iv) Tightening of nuts, bolts and screws.

4.4.7 Servicing of Furniture

Bench tops and tables in the laboratory require constant care. The type of care depends on the materials used for construction. Where wood tops are used, care must be taken to avoid long contact with water and chemicals. Hence

immediate mopping of spillages prevents damage. Occasional application of wax polish makes the surfaces more resistant.

If the surface is highly stained and dented, renovation by a carpenter is recommended. Renovation of wooden bench tops if highly dented is done by sanding or first planing down the surface and then by application of several coats of a good clear varnish (polyurethane forms a more durable and impervious coating but is quite expensive) and routinely polishing with wax. Renovation of formica laminated bench can also be carried out by a carpenter. This would require replacement of the formica by use of appropriate glue. Before the new formica sheet is laid the surface must be thoroughly cleaned and dried.

Other furniture in the laboratory i.e. cupboards, drawers, shelves, and blackboards are usually painted. A schedule of painting (yearly or biannually) should be established which may include the painting of walls and ceiling.

SAQ 4

List the types of simple servicing of equipment that the lab staff can undertake.

4.5 CLEANING OF LABORATORIES AND PREPARATION ROOMS

Cleaning staff, who are usually not scientifically qualified, often perform their tasks early in the morning or late in the afternoon. As a result much of the time they work unsupervised. Clearly, in laboratories and preparation rooms they can be in danger if chemicals, glassware, and equipment are not placed properly. Equipment and containers that are not to be disturbed by the cleaning staff must be clearly identified with '*DO NOT TOUCH*' or similar notices.

One further point is worth mentioning here, and it relates to laboratory design. Cleaning of floors (in particular) and benches is often much easier with the newer styles of laboratory design (which as you will recall from Unit 2 is free standing). Brooms and mops can more easily be used to get at the dirt that collects at the backs of units or along walls. With the more traditional designs, access for cleaning can be particularly difficult.

SAQ 5

Briefly explain as to how free-standing lab furniture makes life easier for cleaning staff.

4.6 COLOUR CODING OF SERVICES

In some sophisticated labs and their preparation room in India and in all laboratories and preparation rooms of developed countries, the service pipes of water, electricity and gas have colour codings which is essential especially in case of emergency. The preparation room of your lab may or may not have

such a system. However if the service pipes in the preparation room are not coded you should try as far as possible to get them coded. In any case you should be aware of the procedure of coding, which is as follows.

All service pipes should have the appropriate colour band of approx. 150 mm marked on them at:

1. the point where they enter a room,
2. any point where they change direction, e.g. at island benches or turns at wall benches,
3. any stopcock or tap, and
4. any visible length of conduit or pipe.

SAQ 6

Why should service pipes in the lab and preparation room be colour coded?

4.7 EMERGENCIES WITH SERVICES

In order to deal with any emergency involving services, it is essential that you know where all the stopcocks and mains switches are located. Labs should have emergency electrical cut-outs located near demonstration benches and near the doors in all labs, preparation room and workshops. However, the important point is that the main switches and stopcocks should all be clearly labelled and the labels should be mounted between waist and eye level, e.g.

WATER STOPCOCK BELOW

It is no use if a stopcock is marked with a tag tied to it in some obscure place, such as behind or under a bench cupboard.

4.7.1 Emergency Procedure

In an emergency that requires all the lab services to be cut off, turn them off in the following order:

1. Local electrical cut-outs.
2. Gas supplies.
3. Water.
4. Remote electrical cut-outs, e.g. the main lighting switch which may be located outside or in the basement of a large block.

4.7.2 Flooding

Water flooding is the most common emergency in science labs. It can be more dangerous in multi-storey buildings as rooms below may also be affected. Use the following procedure:

1. If the flood is severe, follow the procedure outlined in subsection 4.7.1.
2. If the flood is minor, e.g. a leaky tap, turn off the water at the source of the leak.

3. Check the rooms (if any) immediately beneath the scene of the accident (flooding) as well.
4. If water is coming through the ceiling, cover all electrical equipment with polythene or plastic sheets. By supporting them and tying them up, you could create a slope so that it is possible for the water to run off it into a sink or a bucket. Keep an eye on the light fittings as they may get filled up with water!
5. Clear up the flood water as best as you can. In case of a sophisticated lab you may find that one of the machines used by the caretakers or cleaners will be useful for this.
6. Get an electrician to check all electrical apparatus, so that he can ensure that the insulation of electrical units and outlets has not broken down and that pockets of water causing a short circuit are not present.

SAQ 7

Imagine that it is the start of your working day. You enter the lab and find that it is flooded with water. What action would you take?

4.7.3 Gas Leaks

For gas leakage first if possible, open all doors and windows. Also all the electricity supply to power and lighting circuits for the whole block must be turned off immediately, because gas can travel along ducts and collect in pockets. Even if the emergency occurs at night, never turn on the lights as the spark from the light switch may be sufficient to ignite flammable gases. The gas supply must be turned off as soon as a leak is observed. If the source of the leak is not obvious, or if it can't easily be repaired, the local gas supplier must be contacted immediately. Remember to get all services checked and reconnected by a professional person before reusing the gas facilities.

4.8 SECURITY AND VANDALISM

Security and vandalism is a problem not only for the buildings as a whole, but for the labs in particular. The security staff like the watchman is usually responsible for the overall security, but the technician who has more specialized knowledge should be responsible for the lab area. This particular point should be borne in mind as the caretaker will be the person normally called to attend to any emergency. His lack of knowledge may lay him open to more danger than already exists, e.g. vandalism involving the smashing of containers of toxic and highly flammable material. He could quite well switch on the lights in a lab that has a high concentration of flammable vapours without realizing the danger. Fluorescent light switches usually spark, causing ignition with a flash fire or an explosion. The security staff for emergency purposes should have the telephone number of a member of the science staff that he can call for advice or help; or a list of telephone numbers of the science staff should be available with him at an accessible place.

4.8.1 Security of Premises and the Immediate Working Area

A good system of locks for both internal and external doors is essential for keeping the lab premises secure, as locked doors are the first line of defence in security. A locked door is an effective way of delaying intruders. You should never forget to shut and lock the lab door when it is unoccupied. The type of lock is very important. It should be such that duplicate key of it cannot be made easily and so it should not be easy to break into either the labs or preparation room due to it.

It is most important that a record be kept of all keys issued, including the date on which they are issued and returned. A much more detailed record should be kept of keys to places such as poison cupboards, radioactive stores, and the store room. There should be only one key in use, held by a responsible person who keeps the record of the key's usage. This record should give the issue date, the person's name, reason for use (if no other record is kept), return date of the key, and user's signature.

In establishments where people work outside of normal hours, the provision of a signing-in book is important. In the event of an emergency this provides a rapid means of checking if anyone is present in the building.

WARNING: ONE OF THE RULES OF ALL ESTABLISHMENTS SHOULD BE THAT NO ONE SHOULD WORK ALONE WITHOUT INFORMING SOMEONE ELSE.

Security in your immediate working area should involve the equipments as well as the building. Many items are attractive to thieves. To deter the theft of the more obviously saleable items such as computers these should be marked not only with security paint but should be engraved with the name of the establishment and its inventory number in a visible position. An item is less likely to be stolen if it is easily identified and therefore difficult to sell.

Furthermore, we can add that if your laboratory, preparation room or store is on the ground floor, then perhaps it would be better if you cover those windows in them through which most people can look in. This simple action can help remove the temptation of pilferage.

Items such as computers, video recorders, slide and cine projectors should be ideally fixed in position (on a trolley if they have to be used in different locations) to prevent theft. You could survey the market in order to find security systems for these valuable items and if available, get them installed.

SAQ 8

What basic measures should be taken to ensure a reasonable level of security in labs and the surrounding areas, as well as for the equipment contained in them?

4.8.2 Protection from Vandalism

Vandalism and theft have other implications beside the destruction of the building and the theft of saleable items such as TVs, tapes, etc. The entry

into the lab may be to obtain simple chemicals to make explosives e.g. ammonia nitrate, mercury, nitric acid, etc. or solvents for sniffing for drug abuse. In one university lab, illicit drugs were being produced in the open lab for months before anyone realized what was occurring. This may have been the first time that something of this nature has occurred but unfortunately it probably won't be the last. However, it does raise another issue, and that is the misuse of equipment and materials by employees. This really is just another form of vandalism. The problem may be overcome by the adoption of an effective stock control system which can help identify excessive use of a particular material. The problem also calls for more effective supervision of staff.

Other items that could be stolen and which could have serious consequences are hypodermic syringes and needles. Not only is there the problem of syringes being misused for drugs but there have also been cases of children finding them and using them to play doctor. Remember it only needs a tiny bubble of air to kill a person. To prevent the theft of syringes they should be issued only under the strictest controls and signed for by a responsible person. Once returned they should be kept in the preparation room rather than in a drawer in the lab.

SAQ 9

Hypodermic syringes and needles present specific problems these days. What are these problems and how can they be prevented?

4.9 SUMMARY

In this unit you have learnt that:

- In order to run a lab efficiently, good planning is required which involves cooperation of teaching staff and technicians.
- Organisation of practical work/demonstration requires advance information to be given by the teaching or academic staff to the laboratory technician about the particular practical or demonstration to be conducted and full details about requirements and equipment.
- Day to day organization requires that the technicians should be informed by the teaching staff in advance about: (1) number of students (2) list of equipment (3) List of solutions to be prepared (4) list of chemicals needed (5) note of any special requirements or hazards. All this will ensure that proper preparation can be made before the start of experiment/ demonstration.
- Daily cleaning of the lab should be done routinely and after practical/ demonstration. The used and unused materials (chemicals, stain, animal or plant tissues) should be disposed off safely.
- The maintenance of the preparation room as well as lab should be done both on a daily, weekly monthly as well as annual or biannual basis to ensure cleanliness of the lab as well to provide uninterrupted supply of services like water, gas and electricity.

- The prevention of dust, vibrations, corrosion, rust and excessive heat in the lab and preparation room will ensure the maintenance of equipments, apparatus and furniture for a longer period of time. Servicing of equipments and furniture will ensure their satisfactory and long term use.
- The colour coding of service pipes, electricity, water and gas as far as possible should be done as this will prove useful during service emergencies like flooding or gas leaks.
- In case of emergency that requires all lab services to be cut off, the services should be turned off in the following sequence. (1) Local electrical cut outs. (2) gas supplies (3) water supply (4) the main light switch, which may be housed elsewhere.
- It is important that the labs and preparation rooms are secured and guarded both from thieves as well as vandals because these rooms have both expensive as well as dangerous materials.

4.10 TERMINAL QUESTIONS

1. Describe the method of disposal of wastes such as chemical solutions and biological material that accumulate in the laboratory.
2. Describe the method of cleaning the fume cupboard.
3. List the main sources of dust in a lab and suggest measures you would take to minimise entry of dust in the lab.
4. List step-wise, the procedure you would follow in case of gas leak.
5. Describe the security measures you would take to prevent theft and vandalism.

4.11 ANSWERS

Self-Assessment Questions

1. It is important for the technicians to have advance information so that they can have everything prepared and ready before the practicals or lecture cum demonstrations are to be held.
2. Refer to section 4.3 for help.
3. Constant vibration should be prevented in the laboratory area because they adversely affect the equipment kept there. The vibrations cause undesirable loosening and movement of the various components of the equipment. This results in loss of adjustment, precision and accuracy of the equipment.
4. The lab technician can undertake the following servicing of equipment. He can:
   i) Clean the internal components of the equipment by using certain solvents, blow brushes, vacuum and compressed air.
   ii) Lubricate components of the equipment
   iii) Replace bulbs, belts, nuts, bolts and screws of equipments, if necessary.
   iv) Tighten nuts, bolts and screws when needed.

5. Access to floors and walls is easier.
6. Colour coded services are instantly recognizable. This is particularly important in the event of an emergency.
7. You should follow the procedure given in subsection 4.7.2.
8. Your answer should include the following points.
   i) Good quality locks should be used.
   ii) Doors should be locked when the lab/preparation room is not in use.
   iii) Access should be restricted to authorized personnel. Other people should only be allowed to enter under supervision.
   iv) Items which can be easily stolen or misused should, if possible, be kept out of sight.
   v) Inventory number/name of institution engraved on equipment in a position which is clear for all to see in order to deter the thief.
9. The main problem these days is the use of hypodermic syringes for drug abuse. Hypodermics should only be issued under the strictest controls and signed for. They should be kept in the preparation room rather than in an open drawer in the lab.

Terminal Questions

1. Consult subsection 4.2.4 for the answer.
2. Consult subsection 4.3 for the answer.
3. Consult subsection 4.4.1 for the answer.
4. Base your answer on subsection 4.7.3.
5. Base your answer on Section 4.8.