Manuals of food quality control

1. The food control laboratory

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FOOD
AND
AGRICULTURE
ORGANIZATION
OF THE
UNITED NATIONS

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1. The food control laboratory

by
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revised by
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and
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prepared with the support of the
Swedish International Development Authority (SIDA)

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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FOREWORD

The control of food safety and quality is an integral part of national programmes for development. National food control systems are designed to protect the health and welfare of the consumer, to promote the development of trade in food and food products, and to protect the interests of the fair and honest food producer, processor or marketer against dishonest and unfair competition. Emphasis is placed on the prevention of chemical and biological hazards which result from contamination, adulteration or simple mishandling of foods. Also important are the maintenance of general food quality and the control of the use of food additives and food processing procedures.

In order to establish a workable food control system, a national government must:

1. Enact food control legislation.
2. Promulgate regulations to enforce that legislation.
3. Create an agency to conduct the enforcement.
4. Establish food inspection and analysis staff within the agency or agencies concerned.
5. Provide physical facilities including a food control laboratory.

To assist the national governments of developing countries in this process, FAO, with the support of the Swedish International Development Authority (SIDA) has published the series Manuals of Food Quality Control. These are incorporated as part of the FAO Food and Nutrition Paper Series No. 14, and include:

No. 14/1 rev. 1	The Food Control Laboratory (revised, 1986)
No. 14/2	Additives, Contaminants, and Techniques (replaced by No. 14/7)
No. 14/3	Commodities (replaced by No. 14/8)
No. 14/4	Microbiological Analysis
No. 14/5	Food Inspection
No. 14/6	Food for Export
No. 14/7	Food Analysis: General Techniques, Additives, Contaminants, and Composition
No. 14/8	Food Analysis: Quality, Adulteration, and Tests of Identity

In addition, FAO, WHO and UNEP jointly have published many guidelines and other documents designed to further assist developing countries in forming adequate food control systems. These publications include:

Methods of Sampling and Analysis of Contaminants in Food - A Report of the Second Joint FAO/WHO Expert Consultation, Rome - 1978

Guidelines for Establishing or Strengthening National Food Contamination Monitoring Programmes - FAO Food Control Series No. 5 - 1979

Guidelines for the Study of Dietary Intakes of Chemical Contaminants - WHO Offset Publication No. 87 - 1985

Guide to Codex Recommendations concerning Pesticide Residues, Part 2 - Maximum Limits for Pesticide Residues, Second Preliminary Issue - Rome - 1985

Recommended Practices for the Prevention of Mycotoxins in Food, Feed and their Products - FAO Food and Nutrition Paper No. 10, Rome - 1979

Food Standards, Codes of Practice and Methods of Analysis Recommended by the Codex Alimentarius Commission - Joint FAO/WHO Food Standards Programme (several titles)

Food Additive Evaluations and Specifications of Purity and Identity - Reports and Monographs of the Joint FAO/WHO Expert Committee on Food Additives (several titles)

The above publications, and others, are available to persons and organizations. FAO is also interested in receiving comments regarding this volume and suggestions for future improvement. Please send to:

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Food Quality and Standards Service
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FAO wishes to acknowledge the generous support of the Swedish International Development Authority (SIDA), in the preparation of this volume, and the efforts of Mr. J. Weatherwax and Mr. P.G. Martin who were responsible for the preparation of the text.

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6. LABORATORY SAFETY

7. LABORATORY QUALITY ASSURANCE (QA)

1. SCOPE OF THE FOOD CONTROL LABORATORY MANUAL

This manual is primarily a practical handbook on the establishment of a food control laboratory. The various organizational, administrative, operational, and design criteria are discussed in some detail. Also included is a discussion of laboratory safety to stress the importance of safe operation and the inherent hazards always present in an analytical laboratory.

The manual is designed for laboratory management and administration personnel, but the operating analyst can gain good information and insights into the problems involved in establishing and operating a food control laboratory.

The user of this manual should always keep in mind that the information and principles presented are advisory only and represent recommendations on how a food control laboratory may be organized, arranged, etc., not how it must be.

This manual is intended as a guide, to help a new laboratory get off to a good start, or to guide an established laboratory in which work is expanding and diversifying. As time goes by, experience builds up and a laboratory tends to develop new methods, modify existing ones or adapt them to other products. All this valuable information should be retained and, if possible, combined with this manual and manuals No. 14/2 and 14/3 in a readily accessible form. At the same time, the analyst must remember that reliable results will only be obtained by strict adherence to the details that matter and to careful and professional work. Analytical chemistry is an exact science, very demanding on the manipulative skills of the worker at the bench. There is no substitute for experience but it is hoped this manual will form a useful guide while that experience is developing as well as during routine laboratory operations. Any comments or suggestions for improvements will be welcome. These should be addressed to the address given in the Foreword.

The first edition of this manual was written in 1977 by Mr. Peter G. Martin, presently of Lyne, Martin and Radford, Public Analysts, Reading, Berkshire, England. The present revised edition has been prepared with Mr. Martin's support and assistance by Mr. John Weatherwax, retired Laboratory Director for the United States Food and Drug Administration, Los Angeles, California, USA.

2. *LABORATORY ORGANIZATION*

2.1 Establishing the Laboratory

The publication, "Guidelines for Developing an Effective National Food Control System", FAO/WHO/UNEP, FAO, Rome, 1976, details the formation of a food control system embodied in a national food quality control service. The purposes of a national food quality control service are to ensure a supply of safe, nutritious and honestly presented food; to protect consumers from foods which are contaminated, decomposed, adulterated, injurious or packaged or labelled in a false or misleading way; to promote better quality control of foods by food processors and distributors and thereby encourage development of the food industry and to improve export potential and enable better control of food imports.

When consumers and buyers have confidence in the quality and safety of foods, trade increases at both local and international levels. Increased local demand encourages industry and international trade brings better returns in foreign exchange capital. This can also lead to national diets becoming more varied and nutritious with local products often substituted for costly imports. Besides the obvious economic and public health benefits, the advantages in social terms can also be considerable.

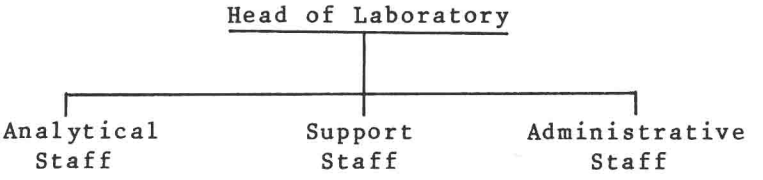
In many government structures there are staff and facilities located in different agencies that are involved in some or all aspects of food control, but their efforts are often not highly effective due to lack of facilities, expertise or an adequate legal or administrative framework. These resources should be brought together into a unified structure in such a way that the personnel are best utilized and have clear objectives with the facilities to carry them out. The result would be a properly linked inspectorate and laboratory with the necessary administrative and legal support including, whenever possible, an Advisory Board to provide guidance and coordination at national level.

This manual deals only with the establishment of the food control laboratory, although it is only one component of a national food control service. It should be noted that for an effective laboratory there must be a correspondingly effective inspectorate. In a few countries there is no provision for an inspectorate and samples are often obtained by the analyst, thereby using potential analytical time. Having samples submitted by the food industry saves sample collection time, but is inherently a bad practice because the samples cannot be assured of being representative.

A food control laboratory is a costly facility to establish, so best results will be achieved if the functions of the laboratory are confined to activities resulting from the enforcement of food law, general surveys on quality of foods, export/import inspection work and work of an investigational nature relating to food quality. However, it may, for reasons of economy and optimum utilization of the facilities, become necessary to take up other selected analytical work provided the laboratory is appropriately equipped. Advice or analysis on a fee basis to local industry may be justified if this does not conflict with statutory duties or other government bodies and there are clear guidelines. Such analyses are carried out for advisory purposes and in no way are a substitute for normal food control work.

2.2 Organizational Structure

The staffing structure of a typical food control laboratory is as follows:



The office of Head of Laboratory (other titles such as "Chief" or "Director" are often used) may include a Deputy if the laboratory staff is sufficiently large. Usually, however, the duties of the Head, in his or her absence, are assumed by a senior supervisor of the analytical staff.

The analytical and support staffs are discussed below in Sections 2.6 and 2.7, respectively. The administrative staff includes all administrative assistance such as a secretary, typing and filing clerks, a management assistant and a librarian (if the laboratory library is of a size to need one). Basically the administrative staff are those persons generally involved in "office" or "paperwork" functions. This staff is very important to the smooth operation of a laboratory. It is false economy to understaff the administrative group because their work often must then be done in part by the analytical or support staffs.

The secretary for the laboratory generally works directly for the Head. It is good practice, however, to make the secretary responsive to secretarial needs of the supervisors.

2.3 Head of the Laboratory

The Head of the laboratory should be a graduate chemist or microbiologist trained in food analysis. A postgraduate diploma particularly relevant to this work is highly desirable. Although the duties of the head of the laboratory are many, some may be delegated and others undertaken by other parts of the food control administration. It is therefore not appropriate to do more than draw attention to certain aspects. The objective of the laboratory is to analyze a large number of samples correctly, quickly and cheaply. This means that attention must be paid to careful spending of the budget, promotion of good staff relations and maintenance of the highest possible level of technical efficiency and expertise.

The laboratory Head may have to give evidence in court or write documents used in court, in which case he must have a thorough understanding of food and related law and court procedure. There will also be involvement in committee work and relations with other organizations. The laboratory Head is usually the spokesman for the laboratory in many instances. The Head must prepare work plans with the inspectorate and overall food control authorities. Sampling plans agreed with the inspectorate should aim at areas of concern and major abuses.

In the earlier years or while the laboratory remains small, the Head of the laboratory is the one who makes most of the management decisions. The Head is also the person who interacts with higher management. This is a most important aspect as the laboratory must be fully integrated into the executive structure in a meaningful way. It would be futile for a laboratory to work in an administrative vacuum, producing results showing, for example, that samples

were contaminated or that there were consignments of food in the distribution chain requiring regulatory action, if the food control organization and inspectorate took no action, or if attempted action was countermanded at a higher level. The executive arm of the government in this area, the food control service, needs the sanction and support of more senior levels of the administration. To play an effective role, the Head of the laboratory must be assured of necessary finance, staff and facilities. When difficulties arise in the supply of these three essential ingredients, it must be possible to bring these difficulties to the attention of persons in positions of higher authority for appropriate action.

2.4 Supervisors

Supervisors should also be graduate chemists or microbiologists with considerable food analysis experience. The supervisor is the on-site manager of the laboratory. Having supervisors assigned to specific units or areas of work permits the Head to more effectively plan (and execute) the total workload of the laboratory.

Supervisors can be expected to do analytical work in addition to their supervisory duties. However, if their group exceeds five professional analysts, it is best not to require additional analytical work except for occasional problem solving and trouble-shooting. A reasonable maximum number of analysts for one person to supervise is 10 to 12. This can be more if non-professional support staff is added.

A supervisor's duties can include many or all of the following:

1. Assisting the Head in overall laboratory work planning and planning the work of the group supervised.

2. Receiving and assigning samples for analysis, within the group.

3. Answering questions and assisting in solving analytical problems posed by individual analysts.

4. Reviewing the reports of completed work and making appropriate recommendations.

5. Ensuring that the group has the necessary supplies and equipment to do the work.

6. Ensuring that proper laboratory safety and housekeeping practices are followed by the group.

7. Recommending to the Head new instruments or equipment needed, and training needs of individual analysts.

8. Taking appropriate disciplinary action when needed to enforce laboratory rules or regulations.

9. Acting to manage the entire laboratory in the absence of the Head.

Supervisors should train one or more analysts in their group to serve as back-ups, to supervise the group in the supervisor's absence. The back-ups should be given some formal classroom training in supervision in addition to on-the-job experience.

A good supervisor is indispensable to the smooth operation of a laboratory. In selecting a supervisor, the Head must keep in mind that the primary job of a supervisor is to manage, so that skills in working with people are more important than scientific expertise. Therefore, a top administrator with

mediocre science ability is most often a better choice than a top scientist who is only a mediocre (or bad) administrator. (This principle holds even more for selection of the Head of the laboratory.) Often the best analysts are given supervisor jobs as a reward for their bench expertise. This not only removes them (at least in part) from their most valuable role as analyst, but it also puts them in the often uncomfortable role of supervisor. This can result in an overall decrease in that individual's effectiveness.

This is not to say that a top analyst cannot be a top supervisor, many fortunate organizations have such persons. They are rare, however, and a Head selecting a supervisor should be willing to accept lesser scientific credentials if the other attributes rank sufficiently high.

2.5 Team Leaders

Another important, and often overlooked, position is Team Leader. A team leader is a senior analyst who has been assigned a small group, usually no more than 4, to do a specific task or type of analysis. The leader has no supervisory functions as such, but is the coordinator of the group's activities and is the contact point for the supervisor.

Team leaders are most useful when a large number of a repetitive type of analysis is to be done in a specified period of time. This could be a specific analytical survey or an emergency public health problem requiring screening analyses. The leader usually works along with the group in addition to the coordinative function. Such experience is often useful to determine if the assigned leader has potential as a future supervisor.

2.6 Analytical Staff

The basic job of the analytical staff is to analyze the samples received and to issue a report. They may also be required to appear in court as fact or expert witnesses to give evidence in relation to a report. They may also be called on to offer advice to industry and trade, to assist in improvement of food quality, or advise on conformity with standards or other legal requirements. This can involve the laboratory staff in factory visits and even requests to carry out experimental work. Whether or not the laboratory undertakes such work will be a matter of organizational policy. The decision will depend on a number of factors, including the availability of alternative facilities, the nature of individual ownership, etc. The integrity of the analyst is paramount, and superiors must be informed of any conflict of interest that arises. As in the case of food inspectors, it is proper for the analysts to have no vested interest in regulated industries. This requirement is mandatory in many countries.

Analytical staff can be drawn from three levels, university graduates, trained technicians from technican training colleges and unqualified staff who have received on-the-job training. The graduates can be chemists, microbiologists, food scientists or food technologists. University degrees are only a starting qualification and there will still be a requirement for specialized training and experience in food analysis. Staff should be encouraged to continue to work for suitable postgraduate qualifications to enable them to compete for higher posts in the laboratory. Specially trained laboratory technicians who have followed a two to three year practical training course in laboratory analysis after completing secondary school can be particularly useful in carrying out a number of routine or even highly complex food analyses. As in the case with university graduates, specialized on-the-job training will be needed for particular types of food analysis.

Some people with little or no theoretical background often show manipulative and practical skills in the laboratory as good or better than university graduates. This type of person is often more happy and fulfilled in carrying out certain routine laboratory tasks than are graduates. Every attempt should be made to encourage such personnel in their work and the laboratory Head should attempt to set up pay scales and other incentives to reward such workers. These workers may also be encouraged to take courses and obtain qualifications in practical aspects of the work, such as glass-blowing, instrument repair, electronics, metal-work and other fields related to the maintenance of laboratory equipment. These skills are often scarce, and just as difficult to master, as those of the graduate analyst and there is every justification for rewarding their accomplishment. It is most important that staff employed for repair operations are qualified and thoroughly trained. In particular, electronic equipment should be serviced and repaired only by qualified instrumentation technicians.

2.7 Support Staff

The support staff of a laboratory are all of those persons working in and for the laboratory who are not conducting analyses or are not involved in administrative duties. Some examples of duties include:

1. Glassware washing.
2. Cleaning and housekeeping maintenance.
3. Disposal of sample reserves (when no longer required).
4. Pest control.
5. Heavy lifting and moving.

Support staff typically have little or no educational qualifications beyond the ability to read and write. However, they must be willing and able to learn not only their duties, but also laboratory safety procedures.

It is most important that sufficient persons are hired as support. The work they do must be done by someone and this is usually an analyst or technician when there is insufficient support staff. There is no fixed module for numbers of support workers, but 15-20% of the number of analytical staff is often sufficient.

3. LABORATORY DESIGN

3.1 General Considerations

When a new laboratory is being built, two people hold the key positions in producing the right building at the right cost - the architect who designs it and guides its construction, and the analyst (preferably the laboratory Head) who explains the technical needs, and works in close partnership with the architect through every stage so that the end result is properly suited to the requirements of the users. It is not often that the analyst has the chance to take part in the planning of a complete new laboratory, more usually he has to make do with old or inadequate buildings. However, these are often more easily extended, changed or adapted as the nature of the work changes, than a newer building, so may in some ways be more advantageous. Indeed, an important point in designing a new laboratory is that provision should be made for future expansion, however unlikely that may seem at the time. The design should also be left as flexible as possible so that changes of emphasis in the work can be accommodated. The laboratory should be located away from urban centres and industrial areas in order to minimize problems of contamination.

The information in this chapter was taken in part from Industrial Research and Development News, VII No. 3, UN, N.Y., 1975. The principles given apply to food control laboratories in general, whether new construction or space converted to laboratory use.

3.2 Basic Structure of the Building

An example of the smallest laboratory that would be adequate for a food control programme is shown in Figure 3.1. This design was originally intended to serve 120,000 people although in general this may be regarded as too small a population to justify a separate laboratory. It is intended to be part of a larger building, but the disposition of rooms can be changed to suit local circumstances. Space for essential services such as solvent storage and the usual administrative support must also be provided. Sample preparation should be carried out as far as possible from laboratories working on trace analysis and microbiology or using sensitive instruments. It must be stressed that the figure shown is only an example. New laboratories must be custom-built to cater for the needs of the situation under consideration.

It is best to allow laboratories to remain open-plan as far as possible, including the areas used as offices. Exceptions are areas where the activities carried out cause contamination or are sensitive to it, such as sample preparation, weighing, microbiology, trace analysis and use of instruments such as gas-liquid chromatographs and spectrophotometers.

Lack of vibration is important and therefore concrete is a better structural material in multi-storey buildings. Steel-frame buildings may cause difficulty with some instruments. A two storey laboratory adequate for a modest food control programme is shown in Figures 3.2 and 3.3. It consists of a ground floor mainly composed of offices and services and a first floor for analytical work. In addition there should be a flammable solvent storage area separate from the building. Workshop and glassblowing facilities are often advantageous and if not otherwise available should be included.

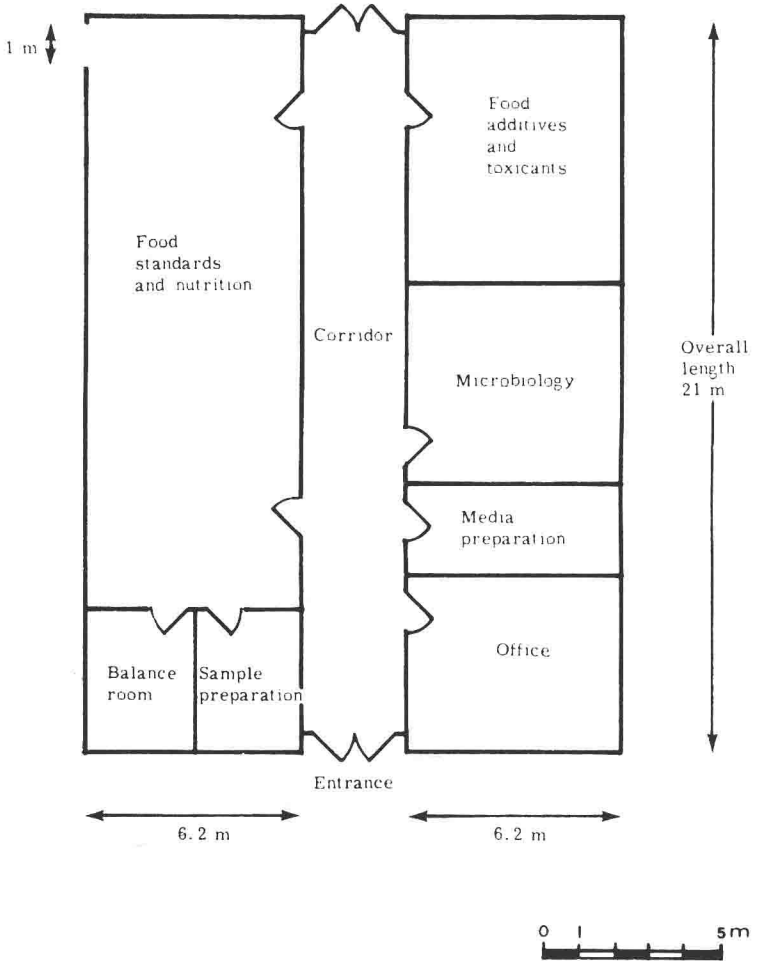


Figure 3.1
A Minimum Sized Food Control Laboratory

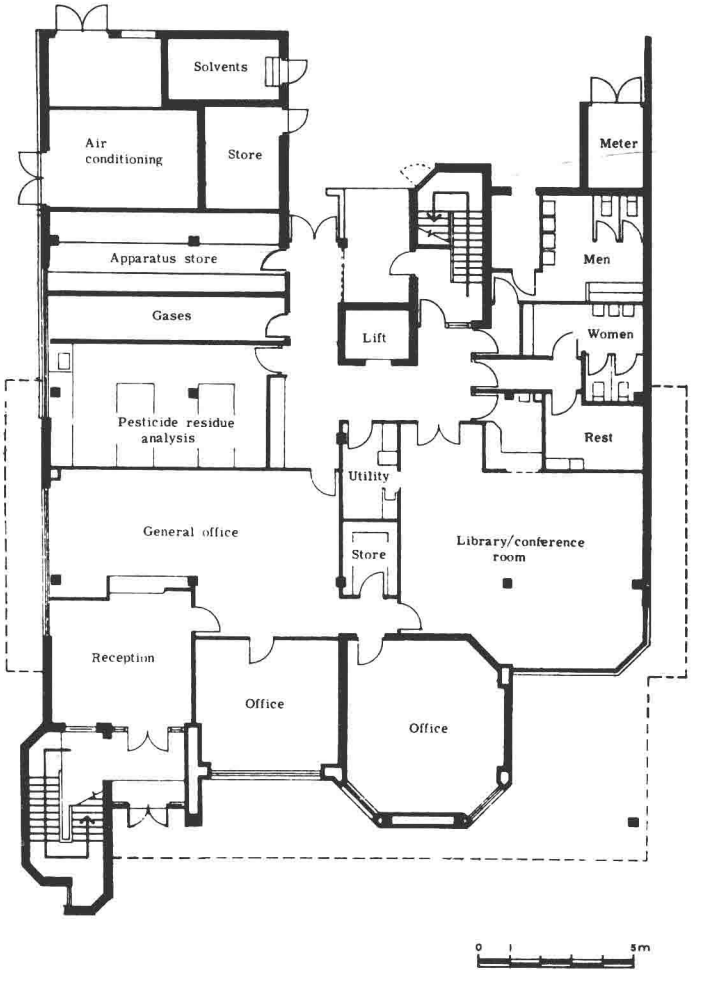


Figure 3.2
Ground Floor Plan
(mainly office and administrative space)

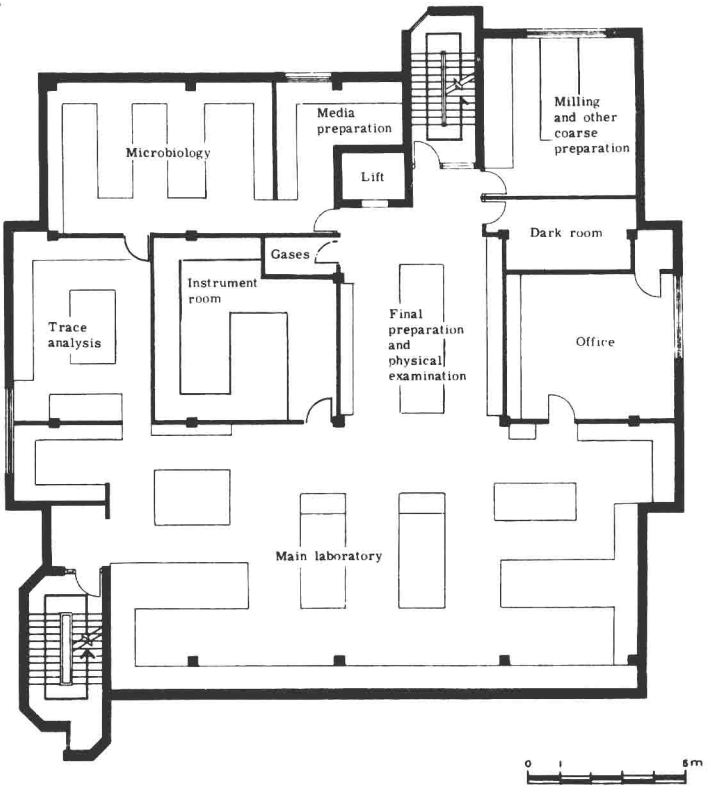


Figure 3.3
First Floor Plan
(laboratory space)

3.3 Safety Features

The building and laboratory design should include a number of safety features including:

1. The fire areas of corridors should be formed of concrete blocks.

2. Services should include a shower sprinkler system near each doorway so that a worker can take an immediate shower, clothes and all, in the case of accidental general contact with corrosive or poisonous liquids or fire.