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ABSTRACT

Designed to serve as a guide to medical laboratory personnel seeking to improve their skills in teaching and instruction in the absence of a suitable course, the manual presents an extensive discussion on instructional techniques. Chapters include: Theory and Practice of Instruction, examining general considerations, individual and group instruction of technicians, and lesson plans; Objectives and Curriculum, discussing training aims and course content; Analysis and Presentation of Material, examining syllabuses and schemes of work, teacher preparation and presentation of instructions, demonstrations, and notes; Choice of Media, discussing a variety of aids; Examinations and Assessment, presenting external, internal, written, practical, and oral examinations and their design; The Student Medical Laboratory Technician, discussing the student's knowledge, skills, attitudes, selection, and induction; The Medical Laboratory Tutor, examining the tutor's character, role, duties, and training needs. All chapters contain reference lists. Appendixes supply specific and detailed information regarding: (1) the functions and responsibilities of various categories of technical laboratory personnel; (2) planning the training of medical laboratory technicians; (3) detailed planning of a training program for medical laboratory technicians; (4) a proposed program for training; (5) an example of a programed learning scheme; and (6) safety in the medical laboratory. (LH)

TRAINING OF MEDICAL LABORATORY TECHNICIANS: A HANDBOOK FOR TUTORS

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WORLD HEALTH ORGANIZATION
GENEVA, 1975

TRAINING OF MEDICAL LABORATORY TECHNICIANS: A HANDBOOK FOR TUTORS

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CONTENTS

INTRODUCTION

Advances in modern medicine have led to an increasing demand for skilfully performed laboratory tests. These tests are frequently the factor on which the final diagnosis of a patient's condition depends. The complexities and importance of such tests require trained technical staff working at various levels of knowledge and skill to perform both elementary and complicated analyses, which often make the difference to the patient between life and death. The training of staff to perform these analyses can no longer be left to chance but must be organized, systematic, and precise.

Since 1966 both the need and methods used for the training of health laboratory personnel have been discussed in various WHO technical reports. Whatever method of training is adopted, be it full-time training in a technical college, laboratory-based training, or a combination of these two methods in the form of a day release or "sandwich" system, the larger medical laboratories involved with teaching will themselves be required to appoint teaching personnel - individuals who have qualified as medical laboratory technicians and who at the same time have an inclination to impart their knowledge and skills to others.

Wisdom demands that more thoughtful and careful attention be given to the developing role of the medical laboratory tutor. It will be a job that requires special skills and substantial effort, and that, one may hope, will receive suitable recognition.

The acquisition of the skills needed to be a good medical laboratory tutor will rarely come naturally. It is frequently suggested that "good teachers are born, not made", the implication being that time and effort devoted to the training of teachers are unnecessary. While it is true that some teachers are born to greatness, the way in which they are bred is still something of a puzzle. In any event, most of us do not aspire to greatness, but seek simply to improve what talent we have that in turn we may impart the knowledge and skills we have learnt to others in the hope that they may beoome more proficient in the practice of medical technology.

The training of medical laboratory tutors can best be achieved by a combination of a suitable pedagogic course and periods of supervised teaching practice. This book is not offered as a substitute for any such training schemes, nor is it offered as an alternative to the many excellent books available on the subject of education and training. It sets out to be no more than a simple instructional manual that will act as a guide to medical laboratory personnel who, in the absence of suitable courses, seek to improve their teaching and instructional skills. It is hoped that as a result they will be able to produce more effective training and education programmes with the resources they have available and that they will thus be stimulated to think of their teaching function prior to attendance at the courses yet to be provided.

Very few medical laboratory tutors possess naturally all the skills necessary for effective teaching or have at their disposal all the resources available to modern technological practice; indeed, in many cases, serious deficiencies exist. It is, therefore, all the more important to learn to use effectively what abilities and resources are available and thereby contribute to the development of more efficient and reliable technological practice in the health laboratories.

1. THEORY AND PRACTICE OF INSTRUCTION

GENERAL CONSIDERATIONS

Words and actions

The job of the tutor is to supply the right amount of the right kind of information to the student at the right time. Words and symbols are the chief means of presenting information in a way that is readily understood by those who have to act upon it. In most periods of practical instruction the teacher will use words:

(1) to tell the students what to do and what to expect;

(2) to guide their movements or explain where they are liable to go wrong;

(3) to give hints on how to cope with difficult techniques;

(4) to encourage students to practise;

(5) to let them know whether they have improved or how they stand in comparison with other students.

Verbal and task learning

Instruction is largely a verbal medium. Words are its counters. The spoken word provides clues to aid understanding and performance. It is important to restrict the number of ideas presented at any one time. The tutor may require the student to undertake preliminary practice with words as "verbal pretraining". For short periods of time the mind can take in ideas at an extremely high rate. Overloading probably depends on two factors: (a) the inability of the mind to retain and interrelate more than a certain number of ideas and (b) the more rapid development of listening fatigue when ideas are presented at a speed that demands a high degree of attention. Similarly, care should be taken to avoid long sequences of motor learning, which can impair the learning of tasks. The choice of words is another problem. In dealing with difficult words it is better to follow the dictum "when in doubt, avoid if you can and, if you can't avoid, explain". Students can often learn a list of simple instructions and proceed to translate them into action. This is an effective way of learning step-by-step skills.

Learning rules and procedures

The giving of detailed oral and written instructions may sometimes be less advisable than the use of algorithms, or step-by-step instructions presented in a family tree format. This "logical tree" method guides the student by a series of simple questions, each of which can be answered by "yes" or "no". This method has advantages in communicating procedural and diagnostic skills.

The basic desire to learn

This varies widely from person to person and especially with the influence of age and responsibilities. For example, an adolescent may join the medical laboratory service as a trainee not necessarily because of a desire to learn but rather because of parental influence or following advice given at school, whereas an adult may seek security or achievement of some precise aim in connexion with his home or family background. In some cases the desire to be competitive, to attain some set standard, or to gain advancement may be the prime motivation.

At times the desire to learn is a short-term one and it exists only to overcome immediate problems. It can be said that the tutor who tries to find out the student's reasons for learning is taking the first logical step towards helping him to do so.

How people learn

The complete mastery of a skill or subject usually depends on three fundamentals:

(1) the initial physical and mental effort needed to acquire knowledge;

(2) the long-term retention of that knowledge;

(3) the ability to put the knowledge to practical use at a later date.

Learning a subject is a process of registering and retaining knowledge. Each depends on the desire to learn, on the methods used to transmit the knowledge, and on the employment of many channels (i.e., the various senses) to make learning more efficient and to build a store of essential information.

A single-channel approach, merely telling or showing a student, may have very limited results. Many students have difficulty in grasping abstract ideas, and merely to talk about the idea will create difficulties. To illustrate by diagrams will illuminate the problem. An efficient tutor uses as many of the senses and abilities of the student as possible to achieve a multichannel transmission. If a particular test that is being described gives off hydrogen sulfide, or involves a change of colour, the student should be encouraged to note the smell or observe carefully the colour temporarily produced.

The use of the senses, reasoning and emulating contribute to the process of learning and when appropriately combined will accelerate learning and lead to an easier retention of knowledge.

Incentives to learning

A basic desire to learn does not always maintain its impetus, especially over a prolonged training period. A good tutor will always be prepared to use some form of incentive, such as:

(1) Regular encouragement and praise for effort when justified. The encouragement may be no more than a brief comment or it may be a written commendation on a piece of homework or practical exercise.

(2) Fostering pride in mastery and providing an attainable goal. The tutor should imbue the student with a real enthusiasm and pride in techniques well done. If he has produced a well stained histological preparation, it should be shown to the other students as an example to be followed.

(3) Allocating certain responsible duties and referring to past achievements during inevitable periods of despondency.

What the tutor can do to facilitate the learning process

(1) Prepare the student to receive new knowledge. Revise previous knowledge, focus attention, arouse interest.

(2) Use the most suitable sensory approach. About three-quarters of knowledge is acquired through the visual sense, the remainder through the senses of hearing, touch, smell, and taste. About two-thirds of skill is acquired through the tactile (and kinaesthetic[a]) sense, the remainder through the senses of sight, hearing, smell and taste.

(3) Arrange the physical conditions for learning to take place - suitable seating, adequate lighting and ventilation, absence of distraction.

(4) Make the subject meaningful. Explain technical terms and symbols.

(5) Give the material a pattern and logical sequence. Organize student's notes and summaries.

(6) Give a purpose for learning. Stress the usefulness of the knowledge to the student. Let him know precisely what is expected of him.

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[a] "Muscle sense" - the sense that conveys information to us about the movements of our limbs and their attendant muscles. It gives us the characteristic "feel" of the movements we make.

(7) Use questions to check sensory perception and to discover whether the student has observed or experienced what the tutor intended. Regular casual questioning of students might also suggest alternative methods of presenting the material. If it becomes obvious as the result of questioning that a student has not grasped a particular concept, try explaining it from another aspect. For example, if the blood coagulation process has not been grasped after an explanation starting with the rupture of the platelets, start instead by discussing the clot and so work backwards.

~~(8) Use the questions to check understanding.~~ Each questioning will also foster confidence and reveal whether the student can interpret or apply what he has received.

(9) Use the blackboard or overhead projector to illustrate the instruction.

(10) Organize revision periods, preferably in the form of short periods at frequent intervals.

(11) Use rote learning (i.e., learning by pure repetition, regardless of meaning and without any attempt at organization) to give early achievement and confidence.

INSTRUCTING THE INDIVIDUAL TECHNICIAN

Individual instruction is given when students in a class are at different levels of training or when the minute detail of the task can be seen only by one student at a time.

Selecting units of instruction

This is governed by a consideration of the learner's capacity to learn and the complexity of the operation to be mastered. Experience suggests that a maximum of 10 minutes' laboratory instruction is sufficient for a student to master at one time. This means that larger operations should be divided into several units of instruction to avoid overloading the learner. Where instruction is, for the sake of simplicity, so divided, it is frequently necessary for the learner to master each unit before attempting the next, and then to perform the whole task to the satisfaction of the tutor.

Even work that must be performed as a continuous process can be dealt with on a unit basis if the tutor remembers that his objective is to take the learner progressively through several stages in the process.

Preparing a unit of instruction

A good tutor presents his instruction in progressive stages and gives appropriate emphasis to important points. This skill can be acquired by planning and by asking such questions as: "What are the stages in this piece of instruction?" and "What points should be explained at this stage?"

A form of note-taking helps in this method of planning instruction. Each stage of the plan, each point to be emphasized, should be critically examined in the light of such questions as:

(1) How might this best be presented to the learner? How can I usefully appeal to as many senses as possible?

(2) How might the difficult points be simplified?

(3) How might skill be developed?

(4) Is the teaching sequence inflexible or might there be a good case for dealing with one stage of the instruction separately?

Finally, at the laboratory bench, a check should be made to see that the right equipment, in proper condition, is available for instruction.

Presenting a unit of instruction

A useful procedure appropriate to most laboratory training is for the tutor to:

(1) outline the subject and promote interest in its mastery;

(2) place the learner in the right position;

(3) proceed stage by stage;

(4) emphasize important points;

(5) perform whilst explaining (using slow motion where appropriate), directing the student's attention to points that might otherwise be unnoticed.

Checking the learner's performance

Have him do the job under your supervision. Correct errors as they occur. Verify his complete mastery of the instruction. Remember that this is the initial instruction. Determine how to supervise the further development of his skill. Practice makes perfect - if the practice is right.

To carry out a skilled task three kinds of information are required:

(1) key points - objectives, sequence of steps, and standard to be achieved;

(2) sensory information from the task itself (details of the task that have been seen, heard or even smelled);

(3) assessment of results - confirmation that the standard has been achieved.

Speed and accuracy are generally the objects of practice, but the distinction between learning to practise fast and learning to practise accurately depends on whether speed of performance materially affects the nature of the task and what limit or tolerance of accuracy is needed.

Example of breakdown of instruction

Task: To determine a patient's bleeding time by Duke's method.

Principle of method. The duration of bleeding from a standard cut is measured. The bleeding depends upon the elasticity of the blood vessel wall and upon the quality and function ability of platelets.

Stages	Key points
1. Prepare all apparatus well in advance so that it is immediately at hand (stop-watch, sterile needle, filter paper etc.).	Why sterilize the ear? What risks are there in not using a sterile needle?. (infective hepatitis?)
2. Warm the lower part of the patient's ear.	What effect does warming the patient's ear have? Will it affect the result or not?
3. Sterilize the ear with sterile wool and alcohol.	Will the depth of the wound affect the result?
4. Prick the ear firmly to a depth of 3 mm and start stop-watch.	How can you standardize this? (Practice and use of spring lancet)

5. Remove drop of blood at half-minute intervals by touching with filter paper.	How long does the maximum rate of flow last? (30 sec - 2 min). How long does it take for normal bleeding to stop? (usually 5 min).
6. Clean up wound with alcohol and sterile wool.	Would you take any special care if you were performing this test on a patient whom you know already is suffering from a bleeding disorder?

INSTRUCTING GROUPS OF TECHNICIANS

Optimum size of group

The number of students that can be taught effectively will vary with the type of task. Small complicated tasks will allow for only a very limited number. For example, the dissection of a mouse or guineapig should be performed with a small group; in a large group many will not see and therefore will not be instructed and will become bored.

Planning the instruction

Step one: break down the task

Step two: analyse each stage and key point, and formulate questions. Each question should encourage reasoning and should aim at guiding the student's thoughts along the lines of those of a technician.

Conducting the instruction

(1) Position the group (students should be placed as near by as is practicable so as to see as well as possible)

(2) Pose the questions

(3) Perform the task

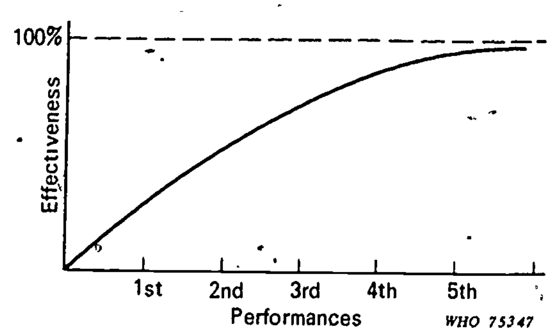
(4) Arrange initial practice (the chosen student is stopped where appropriate by the tutor and his method confirmed or corrected as necessary by the remainder of the group; logical deduction should be the aim.)

(5) Summarize

(6) Supervise subsequent individual practice.

Measuring the effects of practice

If we accept that students are dynamic systems we can set up a simple model for use in measuring the effect of practice. This is the "curve of effectiveness".



This type of curve is typical when the material is relatively easy or uncomplicated or when the trainee's previous experience allows him to organize the new material rapidly and meaningfully. The "curve of effectiveness" never, in fact, starts at zero: new trainees bring to the job basic attitude/skill/knowledge patterns acquired from childhood onwards and these are always "effective" to a greater or lesser extent. What level of effectiveness can reasonably be expected at the end of instruction and guidance is a matter for judgement, negotiation and decision. Formal training in the laboratory should concentrate on tasks that are both frequent and difficult in the actual job; easier tasks can safely be left to "exposure training" and on-the-job guidance. Teaching a student how to use a centrifuge correctly may be left to the senior technician who is responsible for supervising him in the laboratory. There is little point in making a simple technique the object of a lengthy instruction exercise.

The lecture method

A lecture is the fastest but not necessarily the best method of imparting classroom instruction. The minimum equipment required by the tutor includes a fairly large blackboard or overhead projector, provision for the display of models and other visual aids, and a stand for his notes.

The function of lecturing is to present to a group of students the subject in a helpful way which will stimulate further study. The lecture should have three main headings:

(1) Introduction. The aim of the lecture should be stated and should be followed by a brief talk on the general ideas, with brief reference to background reading. The aim should be to focus attention and capture interest.

(2) Development. This is the main body of the lecture. It requires careful preparation. It can be divided into headings and subheadings in helpful sequence.

(3) Conclusion. This consists of (i) brief revision of main points; (ii) blackboard or OHP summary, if not developed during the lecture; (iii) questions from students.

The group discussion method

The purposes of this teaching method are:

(1) to assist students in assimilating information received in more formal settings;

(2) to consider the solution of problems;

(3) to help students to recognize principles that may apply to many different situations;

(4) to train students to organize their thoughts;

(5) to pool students' experiences.

Secondary aims are to develop the student's ability to express an opinion in a reasonable tone of voice, and to listen to the views of others.

The optimum size for a group discussion appears to be between 8 and 15 students. This method offers plenty of scope for experiment with seating arrangements. Essentially the leader and each participant should be visible and audible to each other. The leader should be capable of preparing the topic for discussion, presenting it, ensuring that each member of the group takes part and summing up the main points raised. The methods of presentation are limited only by the ingenuity of the leader, but usually he introduces the topic with a short talk, which can often make a greater impact if it is illustrated by some visual examples.

Profitable group discussions must be planned in advance to follow a definite procedure. A haphazard approach will pay small dividends. The group leader is responsible for the success or failure of a group discussion.

(1) Preparation

(a) Define the objectives of the session.

(b) Analyse the topic. How many logical headings are there for examining this topic? How many can be dealt with in the time allowed?

(c) Plan the introduction. What likely level of knowledge and experience of the topic will the group already have?

(d) Prepare the discussion outline. Write out objectives, brief notes of the introduction, headings and possible items for discussion. Plan and time this outline.

(2) Procedure

(a) Present the subject by giving a brief introduction, stating the subject and also the problems arising. It is well not to read out the objective.

(b) Start the discussion. Read out the first heading, and ask for contributions. (Do not worry if there is no immediate response.) Allow up to 1 min for thoughts. Someone will speak. Do not direct your questions to the brightest member or allow him always to reply first, since this will inhibit the lazy ones.

(c) Direct the discussion. Keep to the point and watch out for digressions. Draw on members' views and experience. Be impartial and do not argue with individuals. Encourage the quiet student by skilful use of questions. As contributions are made, ask questions to ensure that you and the group fully understand the contribution and how it relates to the subject. Ask for examples for further clarity as necessary. Let the students do the talking - otherwise the session becomes a lecture.

(d) Summarize the discussion. Discussions are made worth while by a summary. If suitable, summarize before proceeding to a new heading. Make sure that the group understands and agrees with your summary. Do not overlook the minority opinions.

(3) Effective use of questions

Herein lies the skill in leading discussions. In order to avoid questions being answered by a "yes" or "no", start the question with words like "who", "what", "where", "when" or "how"; they lead to amplification.

Direct questions:

(a) can be used to introduce quiet members;

(b) can be used to break up cliques or stop background undercurrents of conversation;

(c) can be directed to experts for an immediate answer.

Avoid questions that embarrass students.

Indirect questions:

(a) will stimulate further discussion;

(b) can be used to return awkward questions;

(c) will avoid personal involvement;

(d) can be used to get group agreement.

(4) Effective handling of different types of students in the discussion situation

(a) The too talkative student. He may be eager, a "show off", well informed or naturally over-talkative. Do not be embarrassing or sarcastic. Slow him down with some difficult questions. Take his point and offer it to the whole group for comment. In general, let the group take care of him as much as possible.

(b) The argumentative student. He may be an aggressive personality or normally good natured but upset by personal problems. Keep your temper firmly under control and also that of the group. Honestly try to find merit in one of his points then move to another point. Let the group turn down his obvious misstatements. As a last resort, talk to him privately and see if you can win his cooperation.

(c) The overhelpful student, who is really trying to help but in doing so is keeping others out. Use this student for summarizing but cut across him tactfully by questioning others.

(d) The digressor. Re-focus his attention by restating his relevant points.

(e) The inarticulate student, who lacks ability to clothe his thoughts in proper words so that he cannot convey the idea. He needs help. Do not say "What you mean is this," but rather "Let me repeat that," (then put it in better language). Twist his ideas as little as possible but make sure they make sense.

(f) The definitely wrong student. Handle delicately. Say "I can see your point but can we reconcile that with ...".

(g) The non-participant. He may be bored, indifferent, timid, insecure or feel superior. Your action will depend on what is motivating him. Arouse his interest by asking for his opinion. If he is a sensitive student, gently compliment him the first time he speaks.

(h) The obstinate student. He may be prejudiced or has not seen the point. Offer his view to the group. Offer to discuss his view later but to accept the group viewpoint for the moment.

(i) The disturber. The student who appears to show no interest in the discussion and holds a conversation with other students. He may be discussing a related topic or something quite irrelevant. Do not embarrass the students concerned but call one of them by name and ask an easy question, or restate the last opinion expressed and invite comments.

The group discussion method offers the teacher many opportunities to discover the student's understanding of the topic and his personality. To be effective, however, the situation must be well prepared and the tutor needs to learn how to handle individuals.

THE LESSON PLAN

As previously indicated, a well ordered lesson will be produced if a clear and ordered picture of the whole approach is designed beforehand. A detailed breakdown of the lesson should be produced and kept on file, as shown in the diagram overleaf.

LESSON SHEET	DATE:	TIME:
SUBJECT AND LEVEL: TEXTBOOKS:	NAME OF CLASS: BACKGROUND:	NUMBER OF STUDENTS:

TIME	STAGES AND MAIN POINTS	AIDS
	BEGINNING Notes should contain references to (1) revision of previous material relevant to lesson; (2) specific aims of lesson.	
	MIDDLE Notes should show (1) division of work between teacher and student; (The teacher may give a short exposition followed by some exercise performed by the student. This should be noted.) (2) material to be learned; (3) method of presentation (to include teaching aids as listed in right hand column); (4) questions to the class; (5) organization of individual work and practical work.	
	END Know exactly what your last 5 minutes are going to cover.	
COMMENTS		

FURTHER READING

Bruner, J. S. Towards a Theory of Instruction. Belknap Press

Bligh, D. A. What's the Use of Lectures? University Teaching Methods Unit, 55 Gordon Square, London

Holding, D. H. Principles of Training. Pergamon Press, London

WHO Technical Report Series No. 489, 1972. Implications of Individual and Small Group Learning Systems in Medical Education

2. OBJECTIVES AND CURRICULUM

Why training for medical laboratory tutors?

The main concern of the tutor will be that of training, but a skilled laboratory technician will usually lack teaching and training skill when first appointed to his new role. The additional requirement is a skill separate and entirely different from the practical laboratory skills he has previously employed, but one that the average person can learn satisfactorily. For a tutor to be effective, his instructional technique must be of the highest standard.

AIMS OF TRAINING

The tutor should at the outset consider making a general statement of what he aims to teach his students, in terms of skills, knowledge, and attitudes to work. This general statement of intent or aims would not be precise but would indicate the areas of activity to be analysed before a more precise and specific statement is written of what the students should know and feel and be able to do at the end of the course of instruction. An analysis of aims might be:

Skills

(1) Dexterity. The student should show skill and care in handling and manipulating materials and in making and using apparatus.

(2) Numeracy. He should be skilful in handling numerical results and in manipulating numbers and symbols, and be able to recognize and use the mathematical techniques most suitable for the data.

(3) Literacy. He should be able to communicate effectively to others the nature of his work, his results and his thinking, both verbally and in writing.

(4) Accuracy. He should be thorough and accurate in measurement, observation, and recording, and attend to details.

Knowledge

(1) The student should have a sound knowledge of the basic scientific terminology, facts, generalizations, principles and theories.

(2) Comprehension. He should be able to select, restructure and re-order the individual items of his knowledge for specific purposes.

(3) Criticism and analysis. He should be able to recognize warranted, unwarranted and contradictory conclusions and unscientific errors. He should be able to recognize when an abnormal result of a test is due not to the patient's condition but to an unstable laboratory test reagent or other technical error.

(4) Creativeness. He should be able to apply his knowledge in new situations, so that he can devise specific methods for coping with new problems as they arise.

Attitudes

(1) Openmindedness. The student should be ready to accept suggestions from others, and should not prejudge results.

(2) Realism. He should be down-to-earth in his work. He should not embark hastily on a course of action before he has considered the consequences.

(3) Persistence. He should be capable of sustained effort over long periods of time.

LEARNING OBJECTIVES

The appropriateness and effectiveness of the teaching should be questioned continually by the tutor and the students. Unless the precise and specific goals of teaching are set out it is difficult to observe and measure by evaluation and/or examination whether the student has learned what it was intended he should learn. Aims may be stated for lesson plans, units of instruction, and demonstrations, but for the goals of learning to be measurable these aims must be translated into learning objectives which state in action terms what the student will be able to do, under what conditions and at what level of competence at the end of instruction and a period of practice.

An example of a written objective might be:

Perform a haemoglobin estimation on a patient, using a photoelectric colorimeter.

1. Take a sample of capillary blood from a patient and make an appropriate dilution for measurement in a colorimeter.

2. Stabilize the colorimeter and observe the reading of a known standard.

3. Replace the standard with the test solution and observe the readings.

4. Calculate the concentration of haemoglobin in the sample from the patient by the formula

$$\frac{\text{Reading of test}}{\text{Reading of standard.}} \times \text{Haemoglobin content of standard}$$

5. The error must be within $\pm 10\%$.

The statement of objectives in this form should ensure that neither the tutor nor the student is left in any doubt about what is expected of him.

CURRICULUM STRUCTURE

The tutor will construct his teaching programme with regard to his trainees (e.g., their home and educational background); the facilities and equipment available; costs; hospital and laboratory policies; and the requirements of the country in which he is working.

The purpose of training in medical laboratory sciences is to provide a scientific background. Scientific principles should be taught - principles relating not only to health laboratory procedure but also to those basic sciences that are closely akin to the subject. As automation develops in the medical laboratory it will be impossible to separate one from the other. The content of the curriculum will emerge from an analysis of the assignments, activities and procedures the student will be required to undertake in his working situation; the knowledge he requires in order to understand what he is doing; the basic supporting information, drawn from interdisciplinary subjects, that he will require - for example, a knowledge of mathematical procedures in order to be able to answer certain physical chemical problems; and the skills he must possess to perform his duties.

It will be obvious that a considerable section of the curriculum will consist of basic science knowledge - knowledge which the student's limited appreciation will cause him to discard as irrelevant. Therefore if the basic sciences taught are to have any meaning for the medical laboratory student, it is essential that the working examples given should be chosen from his day-to-day experience. To understand how this may be accomplished, one may consider examples of the knowledge required in the following basic sciences:

Mathematics

In broad terms, the student will need to know the theories of statistics and probability. In order to correlate these with his day-to-day experience, examples could be chosen from the medical laboratory field. In statistics the examples might be the frequency of ABO blood groups and the establishment of normal ranges. In sampling, the examples might be dilution factors in blood counting techniques (and the relating of the values back to whole blood), and the Poisson distribution in red cell counting.

He should also learn the use of mathematical methods in solving problems: e.g., logarithms, graphs, and the use of slide rules and calculating machines. This knowledge will be of greater importance to grade A and B technicians than to those in lower grades.

Physics

(1) Dynamics and heat

Motion in a circle as applied to centrifuges; centrifugal force as generated by different types of centrifuge with respect to the size of particles which are sedimented e.g., red blood cells, mitochondria and ribosomes.

Energy and temperature applied to total energy expenditure of a living organism into heat, mechanical work.

Instruments for measuring heat - thermometers, thermocouples and their laboratory applications; effect of pressure and use in autoclaves.

(2) Waves and dynamics

The electromagnetic spectrum with reference to those portions which are of importance to biological processes: e.g., X-rays, gamma rays etc.; transfer of light energy into chemical energy, function of chlorophyll.

Lens, ray action in optical instruments, including microscope; magnifying power eyepiece and slide micrometers; the electron microscope; use of filters in colorimeters on resolution.

(3) Electricity and magnetism

This section of the syllabus may be illustrated by reference to the many instruments in the laboratory.

(4) Nuclear physics

As applied to autoradiography to locate specific cell contents; life of a red cell, uptake of iodine by thyroid.

Chemistry

It is important that medical laboratory technicians gain an understanding of the major concepts of chemistry in a biological context. Relationships between chemistry and medical technology abound.

Practical work should include volumetric analysis, titrations, measurement of pH, exercises in Beer's law, qualitative reactions for common mono-, di- and polysaccharides, including elementary chromatography using the many medical laboratory examples available.

Biology

Medical laboratory technicians will find this subject most relevant of all. However, greater emphasis should be given to animal and human biology than to plant biology.

Medical laboratory subjects

Whilst it is important for the teacher of the basic sciences to make the subject relevant to the medical laboratory subjects of haematology, microbiology, histology and clinical chemistry, it is of equal importance that the teachers of these applied subjects in turn draw on the basic science teaching in the course of their instruction. Links between the basic and the applied subjects must be actively forged. The teacher of histology will find that his colleague teaching biology may already have dealt in some detail with normal histological appearances, and he should use this as the starting point for his teaching of histopathology.

As previously mentioned, it is important to teach the applied subjects using the same approach as that used by many teachers of the basic science subjects. These teachers have adopted the "discovery approach" - that is, the student is allowed to discover for himself as much information as is possible. In this connexion it is a useful exercise to proportion teaching time so that one third is given to learning by group discussion and formal methods of instruction and two thirds to practical exercises. To do this the teacher ascribes to practical exercises all that can be discovered by the student for himself. (If the optimum pH for Romanowsky staining is pH 6.8, rather than simply inform the student of this, give him a range of buffered distilled water samples and let him discover the optimum for himself.) Only material that cannot be taught in practical exercises or by demonstration is finally ascribed to the lecturing technique. The topic will be more easily remembered and understood if (i) the student has discovered it for himself; (ii) the most appropriate method has been used for imparting it. For instance, the most appropriate method for teaching a student how to operate an autoclave is not to dictate the technique step by step, but to demonstrate it to him.

FURTHER READING

Mager, R. F. Preparing Objectives for Programmed Instruction. Fearon, San Francisco

Bloom, B. S. Taxonomy of Educational Objectives I: Cognitive Domain. Longmans, New York

3. ANALYSIS AND PRESENTATION OF MATERIAL

Teaching is concerned with effective and efficient communication and learning. Part of the creative function of the tutor is to analyse the subject matter to be learnt and to organize it in such a way that it will be most easily learnt. He should make a careful analysis of the different ways in which progress is most likely to be made by the student from starting point to final objectives.

SYLLABUSES AND SCHEMES OF WORK

Syllabuses

What is a syllabus? A list of topics covering the requirements of a course. Frequently it is an examination syllabus offered as a guide to tutors, but the topics are not necessarily in any teaching order.

Why have a syllabus? In order to plan work over the duration of the course and in order to examine to a set standard.

Who draws up a syllabus? Committees made up of (i) representatives of the medical laboratory service; (ii) representatives of the examining body concerned. Some colleges have an internal syllabus and examinations which are externally assessed.

When drawing up a syllabus the objectives of the course should be considered. These are conditioned by (i) the needs of the medical laboratory service; (ii) the needs of students; (iii) the time available for study; and (iv) the requirements of professional bodies.

Factors to be considered when divising a scheme of work

(1) Analysis of the syllabus:

(a) Look at the syllabus as a whole; look at other subjects; consult colleagues if integration is required.

(b) Study examiners' reports on previous examinations. These give useful information on questions that gave most difficulty; these sections must be well taught and more time should be allocated to them.

(c) Study past examination papers to ascertain which topics are considered most important, whether there is a choice of questions and how difficult the questions are.

(d) Consider whether the students have any knowledge of a topic from previous years. Often topics are expansions of knowledge gained in the first year of a course. Perhaps they may require less time to teach if they have been partly covered before.

(e) See whether there are any textbooks listed and, if so, which section of these you need to refer to and whether they are available in the library.

(2) Time available: calculate the total time available for study - the number of periods per week and the length of periods. Deduct time for: (i) tests; (ii) revision; (iii) industrial or other visits; and (iv) demonstrations or films.

(3) Students:

Take into consideration the type of student - his age, abilities, and previous knowledge, and whether he has been taught by you before.

Construction of scheme of work.

(1) Rearrange topics so that they are in a logical teaching order.

(2) Allocate time to each topic, giving weight to each topic according to its importance.

(3) Break down topics into teaching units.

(4) Consider the teaching methods to be used, i.e. lecture, discussion, tutorial, practical exercises, etc.

(5) Consider what equipment is required for laboratory work. Order in advance any special materials required.

(6) Determine the visual aids required for each lesson (blackboard, slide and strip projector, cine projector, epidiascope, overhead projector). Order in advance for the date required. Determine whether any charts, pre-prepared notes or film strips will be needed.

(7) Note what kind of activity the class is going to indulge in - notes, sketches, laboratory work, etc.

(8) List the textbooks and references to be used or consulted for each lesson.

(9) Give real thought to homework; make it purposeful and regular.

A scheme of work will provide a plan for the whole course. It will be remarkable if it matches the syllabus in every detail. After the course has been tried, a modification or re-writing of the scheme of work may improve the structure of the course so that future groups may benefit. A scheme of work is not a static plan; it should be subjected to frequent critical examination in the light of the teacher's experience. Difficulties in covering the syllabus may be due to a number of factors: (i) too large a syllabus; (ii) too little time available; (iii) the teacher's enthusiasm for certain topics; (iv) poor structure of the course and/or poor teaching.

PREPARING AND PRESENTING INSTRUCTIONAL SESSIONS

Thorough preparation is the basis of good instruction. To make any piece of instruction interesting and effective requires time and effort on the part of the tutor. A tutor must decide who is to do the work - himself or his trainee? For example, a badly prepared piece of instruction may not take long to produce, but the student will need to work and think that much harder if he is to understand it properly.

Getting started is the biggest difficulty. The following plans should help:

(1) Get the facts. Having chosen the topic, gather all the facts and ideas relevant to it. Textbooks will be valuable as a preliminary means of collecting material. Collect useful data from medical and professional journals and manufacturers' publications. Draw on your own experience. Make rough notes of useful items. Keep in mind your objectives, your students and the time available.

(2) Prune out unnecessary material. Look through the facts and ideas you have collected and reject any unnecessary material. It is useful to divide your material into the following three categories as previously mentioned: (i) the essential - vital information necessary to achieve the objective of the session; (ii) the useful - information which is desirable but which, if omitted, would not prevent you from reaching your objective; and (iii) what is nice to know - relatively unimportant material which, if the time is available, would be of interest.

This process helps you with the timing of your sessions; for example if time is restricted, material from the "nice to know" and "useful" categories can be left out, but never the "essential".

(3) Put the material in teaching order.

(a) Divide the session into a number of stages, arranging these stages in a reasonable sequence. A stage should consist of a self-contained piece of instruction that the student can absorb without difficulty. Confirm that learning has taken place before moving to the next stage.

(b) Consider the introduction and the revision necessary to the session.

(c) Determine the main and secondary conclusions to be reached during the instruction.

(d) Plan the questions you intend to pose and the answers sought from students. Questions should be thought-provoking ~~and should not~~ simply result in "yes" and "no" answers or, at worst, mere guesswork.

(e) Plan the exercises and problems you propose to include in the instruction.

(f) Plan the blackboard or overhead projector work, including the entry of conclusions reached by students.

(g) Use a worksheet ~~divided~~ into three ~~columns~~ headed "Aids and remarks", "Stages and notes", and "Time".

(h) Try not to work from full notes. With practice you will find it easier to work from more condensed notes and to concentrate on delivery. Make note of instructional aids against the appropriate stage.

(4) Pay attention to delivery.

(a) Speak effectively. Speak slower than normally. Be audible to all students. Vary tone, pace, pitch and volume to avoid monotony and to add emphasis. Maintain clarity to the end of sentences. Create the impression that each individual is receiving attention by glancing round the group and frequently "catching the eye" of individuals.

(b) Be understood. Explain clearly. Ensure that technical terms are understood. Carefully chosen analogies can often assist understanding.

(c) Be definite. A positive approach both in manner and words will be the more effective. Negative instruction frequently confuses the students and wastes time.

(d) Create and maintain interest. Let your enthusiasm be evident. Examples of personal experience may help to stimulate interest. Create the feeling that students are learning and liking it.

(e) Illustrate clearly. Well executed blackboard work, clear charts and good illustrative materials make for easier learning.

(f) Avoid distracting mannerisms.

(g) Pose questions. Allow time for the question to be absorbed and considered by each student before naming a student to reply. Encourage sound reasoning and avoid commenting upon the less satisfactory replies. Pass these to other students for further consideration.

GIVING DEMONSTRATIONS

The art of demonstrating is an important skill of the medical laboratory tutor. The aim of demonstrating is to show the techniques involved in fundamental operations and to help develop an appreciation of a skilled performance and pleasure in the completion of an operation by skilled methods. Demonstrations are given when it is necessary for students to learn a sequence of operations to achieve a particular end result.

The group demonstration is based on the assumption that all the students in the class need to know the same thing at the same time and that they all have similar learning ability. The tutor must be prepared to demonstrate to three types of groups: (i) the whole class, (ii) a small group from the class, (iii) the individual student.

The following plan should help to ensure that demonstration is clearly given:

(1) <u>Prepare</u>

(a) Have everything ready - notes, apparatus, instruments, materials etc.

(b) Get the attention of the student.

(c) Announce the exercise.

(d) Explain its purpose and importance (raise interest).

(e) Make sure the student can see and hear.

(2) <u>Demonstrate</u>

(a) As a first step it may help to give a silent demonstration at normal working speed.

(b) Repeat the demonstration broken into parts, again possibly without too much comment.

(c) Give a demonstration with explanations.

(3) <u>Check</u>

(a) Get "feed-back" - you do the exercise following the student's instructions.

(b) Let the student try it out - make him give a commentary while he gives the demonstration.

(4) <u>Practise</u>

(a) Demonstrate to target time and explain quality target.

(b) Have trainee practise to target.

(c) Supervise practice.

<u>GIVING, TAKING AND MAKING NOTES</u>

Students need notes because:

(1) they provide a permanent, progressive record;

(2) they act as a source of help for tutor and students;

(3) they are useful for revision for tests and examinations.

Tutors require notes:

(1) to build up a store of subject information;

(2) to refer to for administration purposes;

(3) to form a basis for units of instruction.

Notes may be given by the tutor either in full or as a summary. These notes may be taken by the students in a number of ways:

(1) from dictation by the tutor;

(2) by means of duplicated material distributed prior to lecture;

(3) copied from the blackboard, slides or overhead projector transparencies;

(4) made as the tutor delivers his material;

(5) made from book references;

(6) made in recollection as an assignment.

Dictation too often produces badly set out notes, since no mental activity is involved.

Notes given in handout form may be in detail, as a summary, or as a series of headings and key words to be filled out by the students. It is essential that any duplicated notes should form the basis of some assignment to be undertaken by the student.

If students are to make their own notes, it is necessary for the tutor to develop in them the art of note making. He should:

(1) make a critical analysis and selection of his material;

(2) break down his material into individual items;

(3) emphasize important points.

Whatever method of note giving and taking is used, two factors should be considered:

(1) the instruction should include references and key points so that students can recall, revise and recapitulate the topic;

(2) the method(s) adopted should be suitable to the students' learning abilities and not merely convenient for the tutor.

A tutor's function is not simply to pass on information but to help the student to use it. Only through experience of giving instruction will the tutor become aware of the problem of organization of teaching material and the adjustment of methods of presentation to allow for different levels of ability.

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Mills, H. R. Teaching and Training. Macmillan, London

Powell, L. S. Communication and Learning. Pitman, London

4. CHOICE OF MEDIA

The tutor at the present time tends to rely heavily on oral and personal presentation of his subject. However, it is common to complement oral instruction with abstract linear representations, detailed shaded drawings and realistic photographs. Not all students have developed the ability to learn from oral instruction and indeed may not have experienced such one-sided instruction in their previous schooling. The tutor will need to experiment with the use of different media to produce maximum learning. It is readily acknowledged that the effects of audiovisual illustrations on learning depend on the characteristics of the students, the characteristics of the content, and the ways in which the content is organized.

"There is an urgent need for innovation in teaching method, but this is not synonymous with the use of extravagant and complicated equipment. Audiovisual media must not be considered as an end in themselves. They are only teaching aids to facilitate learning, and it is necessary to define their role within the whole field of educational planning. The task of the teacher is to devise a learning situation which will enable his students to meet the objectives of the course. To this end he must select the most appropriate method of teaching. Whether or not he will use audiovisual media to assist him will depend on many factors. These include the subject content, the student level and experience, local facilities and space available and particularly the teacher's own preference and ability. The communications media, old and new, can help him to illustrate and improve the impact of his teaching. Yet it is one of the tragedies of the newer media that they have been often used simply to perpetuate poor teaching methods. The proper use of these media demands understanding, skill and practice exactly as in any other technology. Each method has its advantages and limitations and its particular indications in certain areas of learning. If he is to use them properly, the teacher must be aware of all these factors; he must be able to decide whether or not an audiovisual aid will help student learning in a particular situation. If the answer is no then an aid should not be used. There is all too often a tendency to use audiovisual materials simply because they are available. This is the reverse of good teaching practice and is partly responsible for the frequent abuse of audiovisual media today which brings them into undeserving disrepute."[1]

Each item of audiovisual equipment can do certain tasks. The role of the tutor is to select the appropriate equipment for those functions that it is best suited to perform, according to the needs of the student. This implies a knowledge of what audiovisual equipment can and cannot do in a given situation. The equipment available is described in the following paragraphs.

Blackboard

The most usual and most versatile of visual aids is the blackboard. Only one of the many functions of the overhead projector is as a substitute for the blackboard. The blackboard should be in occasional, if not in constant, use during an oral lesson. If the lesson is one of continuous exposition, each major point should be written down as it is established so that at the end of the lesson the teacher will have before the class a brief but comprehensive summary of his major points. The lesson in the essential features of its anatomy will be before the students' eyes, and if the students make notes of the lesson obviously such a summary will be of the greatest assistance to them. The best way of constructing this blackboard summary is to write during the lesson the points 1, 2, 3, 4, as these points emerge. Sometimes it is convenient to write up a summary before the lesson begins, so that the class is informed beforehand of the aim of the lesson. Students often listen more intelligently if they know in outline what they are going to hear. At other times the blackboard summary may be constructed during the vital process of recapitulation. If recapitulation takes the form of questioning, the blackboard summary that is before the eyes of the students forms its most convenient basis.

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[1] Dowling, M. C., Unpublished document WHO/ET/72.1.

In many lessons, however, particularly in those where the class, possibly after some preliminary explanation, is working individually from books, the blackboard is best used incidentally to explain some process, or some general error, which requires explanation to the class as a whole. Similarly, whenever terms have to be explained or unusual words come into use, they should be written down so that the visual memory of the students may be exercised.

There are certain elementary matters to be considered in the use of the blackboard:

(1) Handwriting should be legible.

(2) If the blackboard is a movable one it should be placed so as to be visible by all the students.

(3) The matter written on the blackboard should be orderly and tidy; it should be restricted to about 6 lines in any one unit.

(4) What is written on it should be large enough to be seen by all students without strain. In the normal size of room the student may be 10 m from the board.

(5) Lettering should have a minimum capital letter height of 2 cm.

(6) Colour should be used to emphasize important points. The aggressive colours, yellow and orange, are best; the more restful blues, greens, browns and purples do not "carry" so well.

Models

These have the advantage, over most other aids, of being three-dimensional. If the model can be taken apart and reassembled by the student, so much the better. Professionally produced models tend to be expensive and over-elaborate for teaching purposes. The model quickly made by the tutor to meet a particular situation is often the most successful. Old pieces of polystyrene are particularly useful in this connexion.

The model can be used to complement and reinforce teaching undertaken through other media. For example, an oral-visual presentation of the parts of the heart could be reinforced by asking students to identify the numbered parts on a three-dimensional model of the heart.

Charts and posters

These are best produced by the tutor in response to a given situation. A good poster should attract attention, hold attention and deliver its message with the minimum of lettering. Charts can be rapidly and accurately produced by means of copying via the epidiascope. Quick-drying poster paints can be used to produce brilliantly coloured outlines. Charts appropriate for teaching medical technology are available free from some of the large pharmaceutical companies.

Boards

Boards other than blackboards - plastigraph and magnetic boards, for instance - use diagrams, letters, numbers and cut-outs previously prepared by the tutor or manufactured. They have the advantage of vivid impression, speed in assembly and flexibility in arrangement. They save time in the lecture room.

The plastigraph offers the advantage of simplifying complicated structures by either peeling off cut-outs or building up a series of overlays on clear sheets of polyvinyl chloride to reveal the details of a structure. Since adhesion is by a combination of atmospheric pressure and static electricity, there is no loss of adhesion with use.

A plastic hooked material is obtainable which will readily cling to certain nylon materials. Adhesion is very positive and considerable weight may be supported by small pieces of this material stuck on with an adhesive.

Magnetic boards are made up of steel sheet backgrounds with card or hard-back cut-outs which have small magnets glued to the back. Rubber-based flexible magnetic materials are also available. Magnetic boards are particularly suited to the movement of objects to different places, for example, in the building up or breaking down of systems.

Overhead projector

This is a daylight projector which employs light from a filament or iodine quartz lamp. The light shines through a horizontal glass plate on to a mirror and then through a lens on to a screen.

Outline notes and graphs for lectures can be prepared on acetate sheet and previous lecture material can be quickly recalled. Difficult diagrams can be projected - for example, that of an amino acid sequence. Overlays of a number of acetate sheets can be made so that a build-up drawing of, say; an antibody molecule or a diagram of a haemoglobin molecule can be rapidly presented and equally rapidly taken down. Specimens can be placed on the glass plate and a silhouette projected on to the screen. Where a good quality screen is employed it is possible to compare a whole range of 35 mm transparencies.

Materials for overhead projection:

Pencils - good quality grease-pencils.

Pens - water-based so that erasing is easily achieved. A wide variety of felt markers is available.

Ink - normal drawing inks do not flow very freely on the acetate or glass sheets. For permanent transparencies, acetate inks, which etch into the plastic, are available.

Writing surfaces - acetate sheets or glass may be used. The surface to be written on must be transparent. Acetate is the commoner of the two materials mentioned above for overhead projection work. It can be purchased in rolls, books, or loose sheets. Also useful are old X-ray plates which have been washed in sodium carbonate.

Self-adhesive colour sheets - transparent sheets, some printed on acetate, some on polythene, can be used for making up a transparency. If it is decided that a transparency is worth making, a choice must be made between producing (a) a single transparency, or (b) a number of transparencies, i.e. overlays. The visual aid should be simple and readable from student positions. Factors to consider are (a) large enough writing, and (b) effective use of colour. With hand-made transparencies it is helpful to (a) place a ruled sheet of paper under the acetate to provide guidelines and (b) limit your text to a maximum of 10 lines and have no more than 6-7 words on a line. (As a guide - place the transparency on the floor and stand erect. If you can read it without difficulty from this position, then the transparency should be good for overhead projection under normal conditions.)

Easy copying methods are available for transferring printed material to a transparency, but, in the majority of cases, alterations are required for effective adaptation, e.g., (a) complex book illustrations have to be divided into digestible units through the use of overlays when using the overhead projector, and (b) lettering which is readable on the printed page may not be capable of being enlarged sufficiently on the screen to permit all students to read it. Production of transparencies by photographic means can overcome the problem.

Enlargements can be made from any original, using a camera and enlarger. Production of such a positive transparency involves (a) taking and processing the film to produce negatives; (b) printing the negatives on to film, using an enlarger; (c) processing and mounting the film for use on the overhead projector. Photographic tints may also be used for producing colour on large areas of transparencies.

Slide projector

Slides (35mm) are useful for showing pictures of minute detail e.g., microscopic cytological detail, bacteria in pathological material, blood cells in health and disease, histological appearance of tissue.

With automatic projectors, slides are selected, placed in a magazine which is loaded in the projector, projected and focused by remote control. Recall of any slide is possible. Slides are superior to film strip because they can be edited and more easily kept up to date. However, film strips are cheaper and from these it is possible to prepare one's own slides.

Slides can be projected automatically by coupling with a taped commentary on a tape recorder and projector unit.

Cine projector

There is equipment to project films of 8 mm or 16 mm gauge. Film can be used to show objects and processes that could not be shown in any other way. Films can make use of (i) time-lapse photography to condense life cycle (weeks and years into seconds); (ii) slow motion photography; (iii) magnification, e.g., the dissection of a small mammal, which in practice is difficult for a large group to observe.

The film of a demonstration or technique can be edited so that only correct technique and procedures are illustrated. It may only be necessary to show that part of a particular film which is appropriate at the time, in which case the tutor should not hesitate to be selective.

In order to gain the maximum advantage from the film the tutor should carefully introduce it, indicating to the students the special features to be observed. Immediately after the showing of the film, the students should be invited to comment, so that the tutor may ascertain whether the important points have been perceived.

Many commercially produced films are now available, and tutors should inquire about catalogues from all the major pharmaceutical companies in the area. Previewing by the tutor is essential. The following check-list will aid the tutor in an appraisal of films:

(1) Consider

(a) title

(b) details of audience (age, ability, aptitude, background, and course being followed)

(c) running time

(d) cost of hire or purchase

(e) content (whether material is well selected; satisfies educational objectives; is accurate and up to date; is controversial or emotive; emphasizes the relevant points; crams too much into the time available)

(f) quality (whether photography is good; colour is realistic; sound effects are good).

(2) Decide whether the film/programme

(a) was generally well received by the audience

(b) was too long or too short

(c) did adequately what it was designed to do.

(3) Decide whether the programme notes, if any, were

(a) adequate to brief the group

(b) suitable for the audience.

(4) Consider how the teacher should follow up the film programme.

Episcope

Opaque projectors have been greatly improved; they are now lighter and some can be used in semi-blackout conditions, although they are used mainly to transfer diagrams from books on to blackboards or charts.

Microprojector

This usually consists of a bright light source illuminating a normal microscope system, the image being either thrown on to a viewing screen placed at the eye-piece on the microscope or on to a separate screen. The apparatus is useful for illustrating microscopic appearances, using low power objectives. Only high quality expensive systems are adequate when using oil immersion objectives with large groups.

Tape-recorder

This is a versatile item of equipment. It can be used (a) for repeating lectures or broadcasts at more convenient times; (b) for use as a teaching machine where oral responses are feasible; (c) for adding commentaries to slides, filmstrips and cine films; (d) for recording experimental data.

The cassette recorder consists of a small plastic case containing narrow gauge tape. Using a cassette eliminates tape threading and its compact design increases its portability.

Closed-circuit television

This is a useful aid for showing small-scale demonstrations, dangerous experiments such as those in which radioactive materials are used, and objects under a microscope. Dissection and the taking of specimens from constricted areas such as the nose and the throat can be brought before a whole class of students as and when required.

We have found closed-circuit television useful in teaching microscopy by placing the camera in the correct relationship to the microscope. It requires experience in setting up, and ~~suffers~~ from the fact that colour cameras and sets are expensive, so that the images are usually restricted to black and white. Where colour is available it is superior to the microprojector.

The good teacher is well aware of the constant need for programme revision and improvement in teaching method so that his student group will learn the subject more quickly and effectively. Can closed-circuit television help him in his tasks; if so, how should it be used, how much does it cost and what are its advantages and disadvantages? These and other questions must be answered before an investment is made in television equipment.

What are the capabilities of closed circuit television? The following paragraphs list a number of the outstanding capabilities of the television medium, together with some specific indications for use in teaching.

(1) Magnification of image. There are many situations in teaching where image magnification can be of immense value in improving student learning. An effective screen demonstration in anatomy or of the intricate details of an experiment in physiology enables each individual student to see the whole area of operation considerably enlarged. A demonstration of pathological specimens gains much from its enlarged image on the screen and, through the simple attachment of television camera to microscope, the entire class can see clearly histological or pathological material at whatever magnification is appropriate.

(2) Multiplication and distribution. For large classes it is possible to place an appropriate number of receivers in series so that every student has a clear and uninterrupted view of the screen. A particularly important talk or demonstration can also be made available simultaneously to students in many different parts of the faculty. The advantage of the medium's capacity for distribution lies in bringing large numbers of viewers into situations which are either cramped or in some way inappropriate for the presence of more than one or two persons. There are many examples in medical teaching which come within this category.

(3) Ease of filming for simple sequences. Except where expensive productions are required, television normally demands no special lighting. More and more equipment is becoming available which is portable, battery-operated and capable of being set up and used at a moment's notice. This means that an emergency can be recorded without holding up treatment. In comparison with normal movie film, television possesses also a number of other advantages. There is automatic image/sound synchronization. The absence of need for development and printing allows an immediate play-back from videotape (which is recorded directly and stores both sound and picture). It is of little importance if reels are spoilt; they can easily be reshot and the unsatisfactory sequence is wiped off the tape during the rerecording.

(4) Immediate play-back. Unlike ordinary film, the videotape is a recording which can be played back immediately. The usefulness of this for teacher training (micro-teaching) or for teaching students the techniques of patient interviewing is self-evident. The latter use is by no means restricted to students and many psychiatrists welcome the opportunity of viewing their own performance and of discussing it with their peers after, for example, a psychotherapy session. By linking the camera up with an intensifier in the X-ray department, immediate or later play-back of such procedures as barium swallows and heart catheterization can be provided for teaching purposes. It is interesting how, even when the image is recorded, the television screen gives the impression of immediacy. The "eye to eye" contact between the demonstrator and viewer is a vital element in ensuring the success of this medium, which demands from the teacher a rather different technique from that to which he is accustomed in the classroom.

(5) Visibility of television screen without room blackout. This is a particularly important advantage as it means that the medium can be used without all the preparations usually associated with traditional film showing. It is true that where rear projection screens are available for films this advantage no longer applies, but few faculties have so far equipped themselves for this type of projection.

There are a number of minor limitations to the medium of closed-circuit television which need to be recognized by faculty staff. The image is, in general, inferior to that of film, although this disadvantage is usually more than outweighed by the ease and speed of production. When a recording is transferred from videotape on to 8 or 16 mm film, any poor quality in image becomes more obvious. However, many unusual or emergency situations could never have been recorded if reliance had had to be placed on filming, with all the special lighting and other procedures which the latter involves. Editing of tape is difficult and on play-back it is not always easy to locate the beginning and end of a particular sequence. Videotapes will deteriorate eventually after continuous reuse and they have therefore to be considered as expendable items. The problems of incompatability of play-back equipment become important only if it is intended to run an exchange system between different faculties or to borrow videotapes from some central library.

Programmed learning

Programmed texts which present a particular topic or subject logically in steps suited to the comprehension of the students may be used to take much of the repetitious work off the tutor, for example, by presenting laboratory rules and procedures through increments of information connected to progressive questions and answers which allow the student to check if his answers are right. Programmes may be devised involving students in practical work or group tutorial sessions with a tutor as an essential part of the structure.

Learning programmes are useful for self-learning exercises by students between attendances at formal courses of instruction.

An example of a "linear" programme is included (see Annex 5). This follows the pattern developed by Mr B. F. Skinner of presenting the subject matter in small quantities, testing the student's understanding, and informing the student immediately whether his response is correct before he moves on to new material.

One by-product of programmed learning has been the appreciation of the need for a more systematic approach to learning, which requires (a) a statement of objectives; (b) a more detailed analysis of the material to be learnt; (c) the selection of appropriate media for assisting learning; and (d) the design of measuring instruments to test and evaluate results and to ensure that the objectives have been attained.

In certain learning situations where teachers are not readily available - for example, in continuing education for technicians in service - the feasibility of the design and use of individual learning materials should be explored.

Teaching effectiveness can be increased by enthusiastic tutors who are willing to experiment with methods, techniques and equipment. Recent curriculum developments have brought changes in both content and methods of teaching. Ideally the tutor, working either as an individual or as a member of a team, must vary the subject content and approach to the needs of the learner.

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5. EXAMINATIONS AND ASSESSMENT

Examinations play an important part in most teaching programmes and are used by teachers for different purposes. The teacher may use internally set examinations (those set by himself or his own establishment) to test the students' progress and also to test whether the teaching process is efficient.

External examinations (those set by committees or bodies other than the teaching institution) are most frequently used for awarding a recognized qualification, which in itself is accepted as a means of qualifying for a professional vocation.

Whether the examinations are internal or external, it is important to question the purpose of all examinations with which we are associated in medical laboratory technology.

(1) Is the aim of the examination to select the candidate to go on for a further period of study? As such, is it an intermediate examination in a series of steps to qualification?

(2) Is the examination to act as an incentive? There is general acceptance of the fact that harder work is accomplished when there is a clear and time-controlled aim in view.

(3) Is the aim of the examination to measure the amount learned in a specific period of time?

(4) Is the examination itself meant to be one of a number of different methods of teaching?

(5) Will the examination measure attainment? If it is an examination which is related to the individual's right to be considered a qualified technician, then it must set a minimum standard of competence to which the technician must attain before being allowed to practise medical technology.

Whatever the purpose of the examination, it is important that the student is made aware of his performance and in particular, his weaknesses as revealed by the examination.

EXTERNAL EXAMINATIONS

In general, examinations set and marked by bodies other than the teaching institution are qualifying examinations, and it is important to realize that they therefore involve many interested parties other than the tutor and student.

In the first place, the general public is interested in the standards of the examination. Because the laboratory technician must have a high standard of technical ability in the interests of public health and safety, the public itself will require assurance that this high standard is measurable before ever the technician is allowed to practise his skills on material from human beings. Public interest is usually represented by government boards and departments, which require evidence that the examinations, along with the teaching and training schemes jointly conducted by the college and the hospital, measure up to a required standard.

Secondly, the employing authorities, as represented by the pathologist and other senior staff, will be interested in the examination since they are depending, in some measure, on the system to select for further responsibility and promotion those who are competent and reliable.

Thirdly, the examination may be linked to membership of a professional body of medical laboratory technicians. This body will be anxious to set and maintain approved professional standards and accept into its membership only those who attain such a level. In this way it will be able to equate itself with other scientific and professional bodies within its own country and at the same time take its place alongside international associations of medical laboratory technicians.

In many countries examinations linked to qualifications are usually set externally by a professional body or group of experts selected by a government department with a responsibility for health affairs. This system presents some difficulties, particularly in the early stages of a new educational scheme. The tutor is required to discover, by a process of trial and error, the emphasis that is required for different sections of the syllabus. For example, if a haematology examination allocates 20% of the questions to the topic of coagulation studies, and the tutor has allocated less than 5% of his teaching time to this area of knowledge, the students will not be able to demonstrate the depth of understanding of the topic required by the examiners. The problem may be overcome in part by examining bodies clearly indicating the emphasis required to be given to each section of the syllabus, as well as providing a statement on objectives. Furthermore, the examiners should provide, in advance, specimen questions along with the corresponding marking schemes. (Questions without marking schemes are meaningless. A marking scheme should indicate briefly the answer expected and the marks allocated to each section of the answer.)

In some countries qualifying examinations are set by the tutors, who in turn submit the papers, along with the marking schemes, to recognized expert assessors. It is the external assessor's function to ensure a national parity by comparing the papers submitted by one centre with those of another. He will ensure that the examination adequately covers the syllabus and does not overemphasize areas of work in which the tutor has a particular interest, or ignore those topics of which the tutor has ~~only a meagre~~ understanding. The assessor will also be responsible for ensuring that the examination maintains a similar standard in successive years while avoiding undue repetition. Apart from scrutinizing the examination papers he will also check the marks allocated by the teachers to the candidates after the examination scripts have been marked.

Where tutors are responsible for setting examinations for external assessment it is profitable to establish "moderating boards" of local experts who are able to represent the interests of various bodies associated with the examination system, viz., professional bodies and registration boards. These boards help to dispel the locally created suspicions that question the power, integrity or ability of the tutor. It will thus serve to make the examination an acceptable mechanism on which to base promotion. In any event, the author of a question paper is not the best judge of its clarity, accuracy, relevance, and importance, so that a review by responsible colleagues is of great value in constructing effective examinations.

Whatever the system, there must be a free interchange of information between examiners and tutors. The examiners or external assessors should present the tutors with a detailed report after each examination, so that necessary modifications to teaching or examinations may be made. No teacher is perfect, and no examiner is infallible. A badly answered question may reflect poor teaching of the topic or simply be a bad question. Tutors, examiners and external assessors should strive to create the maximum cooperation in order to improve the whole examination system in which they are involved.

INTERNAL EXAMINATIONS

It is a badly designed course which requires the student to sit only one set of examinations at the end of the course as a single but formidable hurdle. The whole of the course should be monitored regularly with small internally set tests so that those students who are not making the necessary progress may be noticed by the teacher and at the same time have their own attention drawn to their deficiencies. Indeed, internal tests should be used as part of the teaching process, as a regular incentive to the student to study and maintain a consistent effort, and to help the tutor to recognize his own failings.

Regular internal tests also serve to indicate any weak points in the teaching of the course. In our own experience a number of courses in instrumentation for medical laboratory technicians were frequently concluding with poor examination results. By introducing a series of examinations at regular intervals we were able to discover that the weakness lay early in the course, at the stage when the basic knowledge of physical chemistry was being taught. Pinpointing the weakness enabled us to strengthen and remedy the teaching in this area of work.

DESIGN OF EXAMINATIONS

For examinations to be considered good measuring instruments they should be considered from four aspects - their reliability, validity, objectivity and practicability.

Reliability

This is the degree to which an examination consistently measures what it is constructed to measure. What is sought is a reasonable level of reliability.

Examinations are considered reliable if they consistently produce similar scores when given to the same group under the same conditions. Differences in the conditions under which the examination is held will alter the reliability. For example, a practical examination held in an unknown laboratory may result in the examinee obtaining lower marks than if he had attempted the examination in a familiar laboratory surrounding.

An estimate of reliability may be obtained by

(1) Repeating the examination. This is a useful guide, but it must be borne in mind that some candidates may have benefited from their first attempt at the examination paper to a greater or lesser extent than others. The method is, therefore, open to errors which are difficult to allow for; but it has some merit.

(2) Using parallel or equivalent forms of the examination paper. This method of estimating reliability is based on the assumption that, for the one "subject", two question papers can be constructed which can be considered equivalent. An estimate of reliability is obtained by correlating the two sets of results. If the correlation is high, the reliability is assumed to be high.

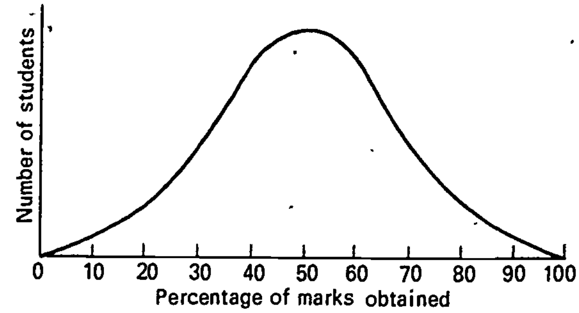
(3) Re-marking the paper. With examination papers where an important factor in the marking of the items is the personal judgement of the examiner, an estimate of reliability of the marking can be obtained by requiring the examiner to re-mark all or a sample of the papers on a different occasion. Here reliability is best thought of as "consistency".

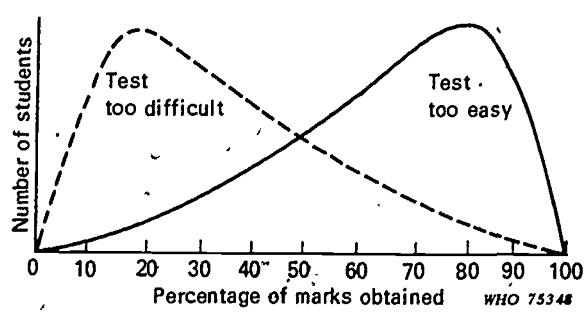
Validity

This is the degree to which an examination measures what it is really constructed to measure. What matters as far as the validity of an examination is concerned is that a question paper should be measuring sound and actual educational objectives.

In any given group of students, most will be of average ability, with a few above average, a few below average and a minority who are either outstanding or hopeless. A valid examination will reflect this spread of abilities by giving most students average marks and a few students good or poor marks. In assessing the validity of an examination paper (or even an individual question) it is useful to construct a distribution curve of the marks obtained. Where validity is good the curve is symmetrical, but where validity is poor the peak is displaced to one side, as shown in the diagram. A valid test should, therefore, be discriminating - that is, it should show a greater proportion of correct responses from the candidates of higher ability.

Validity is concerned with relevance. It should always be asked whether the examination (or the single question) is relevant to the profession of medical laboratory technician.





Objectivity

This refers to levels of marks given to the one examination (or single question) by more than one examiner. Essay type questions suffer from the fact that the same answer, marked by different examiners, will produce different marks, whilst the answer to a truly objective test will consistently receive identical marks from different examiners. An ideal test is one in which subjectivity in the marking is eliminated.

Practicability

This relates to the time and effort it takes to construct an examination, administer it and mark it. It also relates to the time it takes for the student to complete the examination.

Every effort should be made to construct valid examinations linked with detailed marking schedules. Well in advance of the examination date, the proposed papers should be submitted to a committee whose function will be discuss the validity and reliability and anticipate, where possible, any difficulties that may occur with objectivity.

After each examination, the examiner and the committee should scrutinize the performance of each student in relation to every question. From the analysis a permanent report should be kept along with the examination papers for future reference. Poor questions should be discarded and inadequate marking schemes revised. If only a few students managed to complete the examination or most students finished long before the expected time, appropriate modifications must be made in the future.

In advance of the examination students should be made well aware of its format and style. Where changes are envisaged, such as the introduction of multiple-choice questions, adequate warning should be given, along with an opportunity to have a pre-examination practice in order to learn the mechanics of answering new types of questions. A student should never encounter a new examining technique for the first time at an examination of major importance.

Examinations create artificial conditions and as such cannot be relied upon to produce a fair test of ability. Female students undergoing pre-menstrual stress are known to perform below their ability in examinations. Many capable students suffer from examination stress, and ill health on the day or an uncomfortable examination environment will also affect the student's performance. Examiners should be well aware of such difficulties and should strive to eliminate the problems. They should ensure that the examination is fair as between candidates and at the same time ensure that it provides a good incentive to further study. The examiner should also endeavour to make the examination a good test of the student's ability to manage the situation by organizing his time and effort well.

Qualifying examinations in medical technology frequently comprise a combination of written, practical, and oral tests.

WRITTEN EXAMINATIONS

Various types of written questions may be employed, each possessing advantages and disadvantages.

Essay type questions

Examinations relying solely on essay questions demand economic organization of time, the ability to summarize material and the capacity to present the material precisely and intelligently - all skills required of a good medical laboratory technician.

The essay type question provides an opportunity for the candiate to demonstrate his knowledge of ideas, the ability to organize those ideas and communicate them to others. However, essay type questions severely limit the area of knowledge that can be sampled in any single examination. Furthermore, they lack objectivity, in that it is difficult for the examiner to mark the question without being influenced by his own emotions and sentiments. A poor answer from a usually able student may be overlooked because it is not in keeping with the student's normal ability, the examiner thus giving the student the benefit of the doubt.

Objective tests.

In order to avoid the difficulties inherent in essay type questions, in recent years there has been considerable experimentation with objective methods of examination. An objective test usually consists of a series of items, each of which has a predetermined correct answer or answers, so that subjective judgement in the marking of each item is eliminated.

Objective type questions significantly increase the range and variety of facts that can be examined in any single paper and thus make for a more systematic coverage of the syllabus. They also avoid the difficulties experienced with poor handwriting.

However, such questions, if they are to be meaningful and not trivial, are difficult to design and require considerable time (and even inspiration!) to construct. While we would encourage the tutor to experiment with this type of question in informal situations, we would suggest that they should be introduced into formal examinations only after considerable thought and experience.

The various types of objective tests that have been devised are described in the following paragraphs.

(1) "Five choice completion" questions. In each question the candidate is required to select the single best or most suitable choice by circling the appropriate letter in the left hand column of the answer sheet. This is illustrated in the following two examples, in which the correct answer is circled.

(i) Two or three drops of concentrated nitric acid are added to a small amount of powdered calculus and carefully evaporated to dryness. A yellow residue is obtained which turns purplish-red on the addition of a drop of dilute ammonium hydroxide. This indicates the presence of:

A. cystine

B. argino-succinic acid

C. uric acid

D. bile pigments

E. none of these

This type of question usually requires only a single answer, but the candidate should note carefully whether "only one" or "several" of the answers might be right, as indicated in the instructions.

(ii) A microgram is:

A. One-tenth of a gram

B. One-hundredth of a gram

C. One-thousandth of a gram

D. One-hundredth of a milligram

E. One-thousandth of a milligram

(2) "Five choice association" questions. For each numbered word or phrase, the student is required to select the one lettered heading that is most closely related to it and to circle the appropriate letter in the left-hand column of the answer sheet. For example:

A. Emission of light by excited atoms.

B. Absorption of light by unexcited atoms.

C. Emission of light by molecules.

D. Absorption of light by molecules.

E. None of these.

(i)	A	B	C	D	E	Fluorimetry
(ii)	A	B	C	D	E	Atomic absorption flame photometry.
(iii)	A	B	C	D	E	Flame photometry.
(iv)	A	B	C	D	E	Absorptiometry.
(v)	A	B	C	D	E	Nephelometry.

By presenting this type of question in a different way it is possible to obtain five questions in one. It should be noted that for each question either A, B, C, D, or E may be the correct answer. The answers are not merely a process of elimination, e.g., E might have been the answer to all the questions.

(3) "Relationship analysis" questions. These questions consist of an assertion (statement) and a reason. The student is required to circle the letter in the left-hand column of the answer sheet if:

A. both assertion and reason are true statements and the reason is the correct explanation of the assertion.

B. both assertion and reason are true statements but the reason is not the correct explanation of the assertion.

C. the assertion is true and the reason is a false statement.

D. the assertion is false and the reason is a true statement.

E. both assertion and reason are false statements.

Examples:

(i)	A	B	C	D	E	Sodium chloride in the form of saline is commonly employed as an electrolyte in most antigen-antibody reactions because it is the only compound that can be employed.
(ii)	A	B	C	D	E	Rubber gloves can be safely sterilized at 134°C for 3 minutes because the high temperature for such a short time does not cause any significant deterioration in the rubber.
(iii)	A	B	C	D	E	Quartan malaria, which is caused by Plasmodium vivax, is so named because the sexual cycle in man known as schizogony takes 4 days to complete.

(iv) A B C D E — Suitably collected specimens of urine should be cultured within 2 hours of collection because urease active organisms, if present, will hydrolyse the urea present.

(v) A B C D E — All aqueous solutions employed in bacteriology are best sterilized by tyndallization because tyndallization prevents or minimizes oxidative changes due to excessive heating.

(4) "Multiple completion" questions. The student is presented with several statements, any or none of which may be correct. He is required to circle the letters that correspond to correct statements, if any. For example:

Bacteria are classified according to:

A Their morphology and colony formations.

B Specific staining reactions and biochemical activity.

C Antigenic structure and pathogenicity.

D Types of disease they produce, e.g., febrile disease.

E According to their gaseous requirements.

Other types of objective questions are being developed, and the tutor is recommended to build up a reserve of such questions, so that after analysis poor questions may be discarded. The practice in our own establishment is to present the objective questions in a separate examination book. The student answers the questions in the book and returns it to the examiner. In this way the students are prevented from keeping the questions, which may then be used on future occasions.

Marking of objective questions. One mark is given for each correct answer. This is expressed as a percentage of the total number of possible correct answers on the paper. The same process is used for incorrect answers. The percentage of correct answers, minus the percentage of incorrect answers, gives the final mark.

For example, a paper consisting of 100 questions of the five-choice type is presented and only one of the answers for any given question is correct. The total number of possible correct answers in this case is 100 and the total number of possible incorrect answers is 400. Suppose that a candidate has answered 98 out of 100 questions, and out of the 98 attempts he has put the correct answer to 58 questions and the incorrect answer to 40 questions. Then his score of correct answers is (58/100) x 100% = 58%, and his score of incorrect answers is (40/400) x 100% = 10%. His final total is therefore the percentage of correct answers (58%) minus the percentage of incorrect answers (10%), i.e., 48%. It is obvious that students should be discouraged from making guesses at questions.

In order to avoid errors with the use of this type of question the following advice should be considered:

- Establish a small committee to consider the proposed questions. Where this is not possible the questions should be subjected to the scrutiny of a colleague for his criticism.

- Develop skills in preparing questions that measure more than simple recall.

- Review the answers to ensure that they are not self-evident, too easy or unclear. It is also important to ensure that the "distractors" (the wrong answers) are not stupid, thus making the true answer too obvious.

- Build up a bank of questions by noting the good ones, discarding the poorer ones and also by interchanging questions with other teaching centres. Copies of the banked questions should be kept secret from the students. This is best achieved by compiling the questions in book form. The student answers the questions by marking the correct answer on the question paper, which is returned, for marking, to the tutor. Apart from examples of the different types of multiple-choice type of question, the student does not have access to the bank of questions.

"Multipart" questions

These are usually topics on which the students are expected to write brief notes. For instance:

(i) Write brief notes on any five fo the following, explaining their significance in the identification of bacteria:

A	indole	E	fermentation of lactose
B	catalase	F	gelatin liquifaction
C	coagulase	G	bile tolerance
D	urease	H	satellitism

(ii) Compare and contrast four of the following pairs:

A ABO Rhesus blood group systems

B Immune and naturally occurring blood group antibodies

C Tyndallization and pasteurization

D Brownian movement of bacteria and motility

The advantages of this type of question are that it allows the examiner to sample a large area of the syllabus and also to examine the breadth of knowledge of a topic of which the student has only a simple understanding and upon which he can, therefore, only write briefly. This type of question needs careful design and is of only limited use, since it is possible to build into it all that is bad in both essay and multiple-choice questions.

General considerations

Well designed written papers should include a balance of all types of question - the multiple-choice objective questions for wide coverage of the syllabus, and the essay type questions to test the student's ability to organize his knowledge on a given topic and present it in a logical form.

Where possible the written paper should avoid ambiguity. The question and the marking scheme should be subjected to the scrutiny of another individual, since the examiner himself will often find it difficult to see the ambiguity of questions that he himself has set.

It should also avoid testing abilities that could better be tested by practical examination. "Describe in detail how you would perform a Gram stain" is a question best left to the practical examination. However, if the examiner wishes to test the student's understanding of the principles of the test, the question could read "Discuss the principles of the Gram stain and give brief details of the technique".

Finally, it should avoid testing simply for the recall of knowledge. While the student's ability to remember facts is vital, the examiner should also interest himself in the student's ability to handle ideas, to make deductions and see the relevance of lifeless facts to real situations. The question should commence with the basic knowledge and proceed to the practical application - for example: "Describe the principles of bacterial respiration. How may the products of this process be used as a means of bacterial classification?"

PRACTICAL EXAMINATIONS

The medical laboratory technician must above all be capable of accurate technique and reliable performance, even when under stress. It is logical, therefore, that to qualify he must be required to complete successfully a carefully designed and well marked practical examination. High success in a written examination should in no way compensate for a badly performed practical examination.

The design of meaningful practical examinations demands substantial thought and experience, and consideration must be given to the topics described in the following paragraphs.

The aims of the practical examination

The examination should measure: (1) the student's skill in performing particular techniques only; (2) the student's skill in performing particular techniques and his ability in analysing the data derived from the tests; (3) the student's skill in performing the techniques, and his ability in analysing the data and also handling the results.

A question on the topic of "the osmotic fragility of red cells" could be worded in such a way as to measure (1), (2) or (3). To measure (1) the question would be worded: "With the reagents and apparatus provided, perform an osmotic fragility test on the red cells from specimen X". To measure (2) the following words would be added: "What pathological condition do the results suggest?" To measure (3) the question would be enlarged to read: "Comment on your findings and suggest what further laboratory tests you would carry out in order to assist in the diagnosis. Give your reasons for each test you suggest."

In a similar way, a question on blood group serology might read: "Perform an ABO blood group test on specimens X, Y, and Z." For higher grade technicians in whom we are anticipating some deductive ability, the question might read: "Specimens X, Y, and Z are from a mother, child and putative father. ABO group the specimens and state whether you consider Z could be the father of Y. Give your reasons for your decision."

The duration of the examination

It is a mistake in any practical examination to demand too much of the student in the time available, with the result that he becomes rushed, confused, and agitated. As far as is possible, the test should create as near normal a situation as possible, so that, while it is important to know how the student technician will perform under conditions of stress in the laboratory situation, the time allocated must none the less be realistic. To this end the examiner should time his own performance for any particular examination before submitting his students to it.

Practical difficulties that may be encountered

(1) Apparatus. In designing the examination paper, careful assessment should be made of the apparatus required and the demands that will be made upon it. Questions requiring long use of a centrifuge may present problems if the number of centrifuges available are less than the number of examinees. Similarly, blood coagulation questions requiring the examinees to spend long periods working with a water bath may present problems if there is less than one water bath to each candidate.

All apparatus must be carefully tested before the examination. Colorimeters and other sensitive equipment are particularly liable to cause problems, so that spare equipment should be available. Students should be encouraged to report faulty equipment immediately and an appropriate increase in time allowed. The apparatus required for the examination should be placed in an orderly and obvious arrangement within easy reach of the candidate.

(2) Reagents. All reagents should be tested prior to the examination and those particularly liable to deterioration should be tested immediately before the examination. (Blood coagulation reagents are particularly prone to cause difficulties.)

In designing a practical examination the availability of the practical material must also be borne in mind.

The marking scheme

Not all laboratory tests are equally demanding, so that individual questions may carry different allocations of marks. It is important to indicate to the candidates the proportion of marks allocated to each question.

Many practical examinations require the students to record brief details of the techniques used. The marking scheme should make an allowance for this. In examinations which allow the use by the student of practical notebooks or even textbooks, the marking scheme will emphasize the high quality of the performance.

ORAL EXAMINATIONS

Whatever the limitations of written examinations may be in terms of the questions sometimes being ambiguous, unclear or trivial, an analysis of oral examinations shows them to be much more open to criticism than either written or practical tests. The oral examination is difficult to standardize and suffers from possible abuse of the personal contact. Very few examiners have been properly trained in the art of oral examinations, while most have experienced the embarrassment of failing themselves to understand fully the question being put to the candidate by their fellow examiner.

Oral examinations have a long tradition of generating embarrassment and confusion in the candidate because of the sarcastic and humiliating comments of the examiner. An examiner who humiliates the candidate has failed to understand what the examination is about, even though he may be an expert on the subject in which he is examining.

Much of the evidence available about oral examinations suggests that it is a method of examining which has low reliability, poor validity and poor objectivity, unless it is used by a skilled examiner for a quite specific purpose.

However, in spite of its severe limitations, the oral examination does possess some advantages in that it provides direct personal contact with the candidates and as such gives the examiner the opportunity to question the candidate about how he arrived at a particular answer in the practical or written sections. Furthermore, it allows the examiner to discuss with the candidate any mitigating circumstances that may have occurred in either of the previous sections of the examination.

As a general rule, therefore, the oral examination should take place after the practical and written papers and be used as a final arbiter only in borderline situations or to identify the candidate for distinction. Also, it should provide opportunity for simultaneous assessment by at least two examiners, who themselves have given thought and time to oral examination technique and to standardizing the process as between students.

CONTINUOUS ASSESSMENT

Because of the difficulties experienced in devising fair and meaningful examinations, many teachers now make their final assessment of the student on a combination of marks gained during the course and those gained from the examinations.

It is considered appropriate to include in the course regular practical projects which the student may ~~perform at his own pace without the conditions of stress.~~ Each exercise will be slightly more difficult and demand an improvement in skills and abilities as the course progresses. The student is given a practical problem to investigate and left to consider how best he can tackle it. After thought, and reference to textbooks if necessary, he presents a report to the tutor on the method he plans to use to investigate the problem. If his proposed method is considered to be appropriate, after discussion with the tutor he will be allowed to proceed. The experiment is followed by presentation of a written report of his results, conclusions, difficulties encountered, explanation of the difficulties, and any criticism of the whole exercise. The report will also include diagrams, graphs and references.

The marks allocated for such an exercise may be in the following proportions:

For report on how the student planned his project	20%
For results obtained	40%
For presentation of results, criticism and references	40%

A student may be presented with a series of projects, preferably in the second half of his course (when he has had adequate opportunity to improve his practical skills and learned to work with machines and instruments) and the marks allocated for such practical projects may be used in the final assessment.

Any system of assessment that abandons examinations and depends exclusively on course work or vice versa is bound to have difficulties. A suitable balance of marks obtained by both methods would offer a reasonable compromise. A system of final assessment that obtains 30-40% of its marks from course work that is well thought out and 70-60% from examinations has, in our experience, much to commend it. The aim of any form of assessment should be to offer the candidate conditions in which he, equally with other candidates, can demonstrate his abilities.

Just as there is general recognition of the fact that the teacher himself must learn how to teach, so too the examiner must learn correctly to use the tools of measurement and assessment. The whole topic of assessment is fraught with difficulties. These will be reduced to a minimum where there is a willingness to cooperate in all concerned - teacher, examiner, external assessor, examining bodies etc. - and an enthusiasm to break new ground by trying new methods.

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6. THE STUDENT MEDICAL LABORATORY TECHNICIAN

As long ago as 1962 a WHO expert committee recommended that every central and regional laboratory should establish a training programme for technicians to ensure a constant supply of trained staff. It stated: "It is the human element in the service that is the determining factor of the quality of the work. Mere physical facilities cannot replace a good laboratory staff: it cannot be overemphasized that the worth of the service depends primarily on staff quality".[1] The expert committee strongly recommended that laboratory directors spare no efforts for developing training programmes.

Ten years later another expert committee[2] gave further detailed consideration to the training of health laboratory personnel and recommended that the usual qualifications for various categories of technical staff should be as set out below:

Grade or post	Required educational level	Special training required	Promotion possibilities
Technologist (senior technician, level A)	Complete secondary education (12 years)	University or technical college, plus 2 years' practical experience	
Medical laboratory technician (level B)	Secondary education (10 or preferably 12 years)	3-4 years	Technologist (level A) after practical experience and further specialized studies.
Technical assistant (auxiliary, junior, levels C & D)	At least 8 (preferably 10) years of primary education, possibly with some secondary education	1 year	Medical laboratory technician (level B) after further secondary education, practical experience, and further technical studies.

[1] WHO Technical Report Series, No. 236, 1962, p. 24.

[2] WHO Technical Report Series, No. 491, 1972.

The functions and responsibilities of the four categories of laboratory staff (see Annex 1) had been previously outlined in the report of the WHO expert committee published in 1966.[1] It is anticipated that the medical laboratory tutor would be responsible for planning, directing, and assessing the education and training of individuals functioning at levels B, C, and D or (where this nomenclature is not appropriate) individuals of a similar status. Using as a basis the various functions described in the 1966 report, it will be possible to produce a detailed job analysis. It will be necessary, for example, to list the various tests implied in the phrase "performance of all routine and some special laboratory procedures". Furthermore, it will be observed that technicians graded at levels B, C and, to a lesser extent, D are required to exercise supervisory skills, with the result that such required abilities should be listed in the job analysis.

The competent medical laboratory technician is an individual who is reliable and accurate and who has a sense of logical organization. Among other characteristics he should possess a clarity of understanding, technical expertise and the ability to improve both himself and the situation in which he works. He should be versatile and equipped to cope with future developments in medical laboratory practice. To create such an individual requires the imparting of knowledge, instruction in skills and the development of attitudes.

THE STUDENT'S KNOWLEDGE

Medical laboratory technology is not a pure subject, as is chemistry or physics, but is a hybrid of many sciences. Every day the medical laboratory technician encounters and uses facts drawn from the disciplines of chemistry, biology, physics and mathematics. In an attempt to define the area of knowledge required by the technician, some teachers design curricula which are so comprehensive and far-reaching that they end up being equivalent to 4 separate honours degrees combined in one. Obviously, the amount of knowledge with which the technician must be familiar must be limited both by the time he has for acquiring such knowledge and his own ability to assimilate it. It is a mistake to attempt to impart too much in the time available. Clearly, in defining the area of knowledge required by the student technician, we must divide the scientific facts (as we shall see later in greater detail) into 3 groups:

<u>Essential knowledge</u>: In all subjects there is an essential core of information, so that the acquisition of this knowledge by the student becomes the prime aim of the teacher.

<u>Useful knowledge</u>: Information that the student should know. For example, if the technician must know that Romanowsky stains are affected by hydrogen-ion concentration, then he should be given the supporting knowledge of what pH means and how it may be accurately determined.

<u>Interesting, but not essential knowledge</u>: There are many interesting facts in medical technology which are not essential, although they often arouse interest. We often encounter student technicians whose minds are sidetracked by masses of clinical information.

The amount of matter it is possible to give a student should always be divided into what he must know, what he should know and what he could know, and the emphasis of the teaching should follow that sequence. His knowledge should be such that he understands the techniques he is routinely performing to a point of reliability and accuracy, and at the same time that knowledge should be sufficiently broad-based to allow him to change his methods when required by future developments.

THE STUDENT'S SKILLS

Technicians require many skills that can only be acquired by actual performance. It is unreasonable to give a formal lecture on how to make blood films and then expect the students to produce smears as good as those of long-practised senior technicians. Similarly, the making of Pasteur pipettes will require the opportunity to manipulate the glass tubing while under supervision from someone who himself is practised in the skill.

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[1] <u>WHO Technical Report Series</u>, No. 345, 1966.

The prime skill expected of the medical laboratory technician is accuracy (in part this is also an attitude) - accuracy in all his operations, calculations, observations and reports. Upon skills such as these patients' lives depend.

THE STUDENT'S ATTITUDES

Honesty

By the nature of his work the medical laboratory technician will need to be taught to be honest - not merely honest in the sense that he does not steal, but intellectually honest. Should he be confronted with a phenomenon which he has not anticipated, he should not ignore it but continue to study it until he finds an explanation. If, for example, he observes a detail in a urine deposit that he has not previously observed and does not recognize, rather than ignore it he should be honest enough and sufficiently industrious to confess his ignorance to his senior and seek an answer together with him. (To criticize him for his lack of knowledge at such a point will be perhaps to destroy some of his honesty and in the long term the results could be disastrous.) We should encourage in him a spirit of inquiry at all times.

Self-criticism

The student technician should be taught the habit of self-criticism, that of continually evaluating his techniques, his reagents, his surroundings and his own understanding of a particular subject.

Scientific attitude

In all, we are striving to create in the trainee technician a "scientific" attitude. We shall not achieve this attitude solely by filling his mind with masses of detailed techniques or long lists of constituents for bacteriological media, but we shall achieve it if we remember that he is a whole person and that, as such, we are preparing him for a situation that will endure long after individual techniques have been superseded.

SELECTION OF STUDENTS

Most countries stipulate minimum educational requirements for entry to the profession, as outlined at the beginning of this chapter. Some countries will require evidence that a student has passed examinations in specific subjects. The selection of students for work as medical laboratory technicians is no easy task and should not be based solely on their success in a particular examination. We should establish a set of criteria for selection. For example:

(1) How many subjects did the candidate pass at one single attempt? If the candidate has passed only 5 subjects at one attempt he may still be a potentially superior candidate to one who has passed 7 subjects over a period of 3 attempts.

(2) What about his course record? Good homework and classwork marks with a poor examination mark may indicate that the candidate is a reliable plodder but that he suffers from examination nervousness.

(3) What do his teachers say about his character? Very few teachers would put into print on a school report the fact that a student is lazy or dishonest, but if contacted personally they may give some indication of their dissatisfaction with the candidate. (Clearly, if there has already been some evidence of laziness and dishonesty we should ask ourselves whether we are sufficiently confident of our own influence to expect to be able to change the candidate's character.)

A visit to the candidate's school with a description of the duties the laboratory will expect him to perform and the sort of individual required for the job will afford the teachers an opportunity of a carefully considered opinion. It is possible in this way to initiate good relationships between the school and hospital, which may be further encouraged by inviting the teachers to visit the hospital.

After having presented a tidy and thoughtfully completed letter or form of application, candidates are frequently called for an interview. Such an interview should be planned beforehand. Hit and miss methods are never satisfactory. Young people are usually overawed by large committees and therefore not usually at their best in these circumstances. A small interviewing group is preferable, or perhaps even a series of privately conducted interviews, each interviewer separately giving a score to the candidate. Permanent notes should be made of the interview so that the success of the selection process may be reviewed from time to time.

It may help if the student is requested to bring his school notebooks with him when he attends for interview. These notes may be checked for accuracy, tidiness and appearance, orderliness in presentation and originality of ideas.

The interview itself should not be haphazard, but should be planned and purposeful. The interviewers should endeavour to make an objective assessment of the following:

(1) Physical characteristics

(a) Has the student any defects or disabilities that would hinder his occupational performance or make him prone to laboratory hazards?

(b) Does he impress the interviewer in his appearance, attitude, deportment and speech?

(2) General intelligence

(a) What is the level of his general intelligence?

(b) How effectively does he use it?

(3) Attainments

(a) Previous education.

(b) How well has he done educationally?

(c) Previous occupational experience.

(d) Previous occupational attainments.

(4) Special attitudes

(a) Any obvious aptitude for practical things.

(b) Ability with figures.

(c) Ability to draw.

(5) Interests

(a) Intellectual interests.

(b) Practical and constructional interests.

(c) Physically active interests.

(d) Social interests.

(e) Artistic interests.

(6) Disposition

(a) How acceptable does he make himself to other people?

(b) Does he influence others?

(c) Is he steady and dependable?

(d) Is he self-reliant?

(7) Circumstances

(a) What are his domestic circumstances?

(b) Has he had any special problems to overcome?

THE INDUCTION OF STUDENTS

The education and training of the medical laboratory technician commences the moment he arrives at the gates of the hospital. He should understand clearly from that moment that he is joining a team and that he has an important part to play in that team.

First impressions are very important, so that the reception of the student should be made something of an occasion for him. He should be received courteously and time and effort should be given to a period of induction in order to build up in him a feeling of confidence. Soon after arrival he should be instructed in the following matters, and, if possible, given the details in written form:

(1) The conditions of his employment, rates applying to sickness and holidays, and emergency duty arrangements.

(2) Social amenities such as clubs, sports, teams, and activities in the hospital in which he may participate.

(3) Individuals to whom he may go for guidance and advice regarding his personal problems. He should be introduced personally to these individuals.

(4) The layout of the whole of the hospital compound, the size of the complex, its history, future development and specialties.

(5) The medical laboratory technician's place in the whole hospital organization and how his work complements that of other hospital workers. He should be made to feel part of a team.

(6) His own personal career, the courses he will be expected to undertake, the opportunities open to him, and the salary increases likely to be consequent upon various examination successes.

(7) The nature of the education and training courses he will be expected to undertake.

Some teachers and instructors work on the principle that it is better to show their authority from the start by humiliating the new student with some menial or difficult exercise immediately on arrival. It is bad psychology and therefore bad training to give individuals hard and meaningless jobs when first trying to teach them a technical subject.

However, there are some menial tasks that are traditionally part of the technician's training, e.g., the cleaning of apparatus and the tidying of laboratory benches. Where the student is expected to perform these duties he should be encouraged to appreciate that reliable results are dependent, among other things, on good cleaning techniques, and that, when later in his career he is required to investigate the failure of reagents or bacteriological media, an understanding of the cleaning techniques and materials used will make an important contribution to the solving of the problem. A tidy bench will help in the logical organization of the work and will contribute to good practice, particularly in a microbiology laboratory. In other words, even menial exercises should be shown as positively contributing to his training experience.

From the moment the student is selected we should seek to establish mutual confidence and thus set the scene for a soundly based teaching and training situation.

7. THE MEDICAL LABORATORY TUTOR

THE CHARACTER OF THE TUTOR

While it is obvious that the individual appointed to the task of medical laboratory tutor must be a well qualified and experienced technician, he must, in addition, possess the abilities and characteristics that will encourage and motivate the students to learn. His enthusiasm will infect them. His personal commitment to good, accurate techniques and attention to detail will easily communicate themselves to them. Equally, if he is slipshod, they will be slipshod; if he is lazy, alas, they will find it easier to follow his example.

The relationships created in the learning situation influence the students' willingness and enthusiasm to learn. A tutor who arouses fear, anger or frustration in his students will hinder the learning process rather than encourage it. The good tutor must be an individual who encourages all his students to extend themselves with every learning opportunity. To achieve this he must combine his medical technological skills and knowledge with pedagogic training and real quality of character. By nature he must be humble (arrogance will create a gap between himself and the students), considerate and approachable. It will be a rare student who does not recognize and respond to qualities of this sort and benefit by them.

THE TUTOR'S ROLE

A wide variety of schemes and systems exist for educating and training the medical laboratory technician, but broadly they follow one of 3 patterns and in each system the medical laboratory tutor has a key part to play.

College-based training

Some countries require the student technician to have completed a statutory period of full-time college training before engaging in any medical laboratory practice. This system has difficulties, not the least of which is the criticism made by the laboratory staff that the college lecturers are "out of touch" and that their inadequacy in that respect is reflected in the techniques the students are taught. Where such schemes are the practice, the medical laboratory tutor should act as a link between the two establishments. He will ensure that the students produced by the college are the sort of product required by his laboratory. He will be responsible for ensuring that college lecturers are kept up to date with recent trends in medical technology, that the curriculum followed and the emphasis given provides the appropriate background for work in their particular laboratory. For example, overemphasis on medical microbiology to the exclusion of clinical chemistry will be inadequate background for students intending to work in specialist biochemistry units. (A frequent reappraisal of the objectives would prevent difficulties of this nature from arising.)

The task of orienting the student to the laboratory situation, its practices and procedures, and at the same time checking the student's skills, will remain that of the laboratory tutor when the student is first introduced to the laboratory after his college training, and it is perhaps at this point that the tutor's influence will best be felt in schemes of this nature. However, colleges should be encouraged to involve the tutor as much as possible in the course. He should, where possible, be a member of the college advisory committees, examination boards and other appropriate bodies which afford opportunitues for meeting college staff. Furthermore, he should seek frequent informal contacts.

"Sandwich" schemes

In some localities alternate periods of education and training are operated, with the student spending a limited period in the college situation being taught the basic science subjects, followed by a period of training in the applied subject at the medical laboratory. Alternatively, some schemes, allow for both the basic science subjects and the theory of the applied subject to be taught in the college, leaving the responsibility of teaching practical expertise in the applied subject to the laboratory staff. In both of these situations, the so-called "college sandwich periods" will vary both in duration and frequency, with courses involving only a very short period in the college being referred to as "block release". (The difference in duration between "sandwich" schemes and "block release" schemes is arbitrary.)

Although such courses present problems in terms of staffing the laboratory, nevertheless they are perhaps the most rewarding of all schemes. The tutor, again, will need to be in continual contact with the college and should possess a complete outline of the college scheme of work. In this way he will be able to ensure that the student is given practical experience in those methods and techniques which have most recently been taught or referred to in the college. Synchronizing the laboratory training scheme with that of the college education process is difficult, but a real effort should be made to coordinate all aspects of work carried on in both establishments so that the student sees the overall scheme as a progressive and organized development.

"Day release" schemes

In localities in which there is a technical college of appropriate level within reasonable travelling time of the hospital, it is possible to operate "day release" schemes of study. These require the students to attend the college on one day per week throughout the academic year. As with "sandwich" schemes, the division of responsibility for different aspects of the syllabus varies from country to country. Sometimes the college is responsible only for the basic science subjects; occasionally it will be responsible for teaching the applied subjects also. In the latter case, it is usual for the college to employ, on a part-time basis, local senior technicians to teach the specialist subjects.

As far as both "day release" and "sandwich" schemes are concerned, the tutor will need to strive vigorously to prevent any division between the college and the laboratory aspects appearing in the scheme. Senior laboratory staff, as well as the students, should be encouraged to see the college experience and the laboratory training as one unified scheme aiming at a single goal - that of producing a trained, competent medical laboratory technician. Chemistry teachers should be expected to encourage the same passion for accuracy as is required by those practising clinical chemistry. The biology teacher should be encouraged to expect the same standard of cleanliness in his apparatus as would be expected in the hospital laboratory. Equally, the college teachers will hope for something of their approach to teaching to be reflected in the medical laboratory tutor's methods, so that, as they in their section of the course are relying less on learning by rote and more on the student's ability to learn by discovering information for himself, so too some evidence of this approach may be reflected in that of the tutor.

Between each college period the student will probably be given private study, essays and other forms of homework. The tutor should spend that intervening period ensuring that the private work is done consistently, so as to prevent the student from postponing his effort until just before his return to college. Tutorials and discussions, preferably on an individual basis, should be arranged during the inter-college period to ensure that the students have understood the college work. Thus, the inter-college period should be regarded by the student as part of the continuing process, with the tutor helping to set the pace and pattern during this period.

When it comes to teaching medical technology, the tutor should endeavour to introduce each particular topic by commencing with fundamental scientific facts as taught by the college teachers. For example, applied microscopy should commence with the principles of light as taught by the physics staff. Indeed, the whole philosophy of the course should be directed along these lines and be reflected even in the final qualifying examinations, with individual questions proceeding from the basic scientific concept to the applied method.

As with "college-based" training schemes, again the tutor should be actively involved with the college boards of studies, examination boards, progress committees and other similar bodies. Similarly, frequent reports of the student's performance in the medical laboratory situation should be supplied by the tutor to the college teachers so that the overall performance of the student may be assessed.

Laboratory-based schemes

In some countries, any form of college education will be either impossible or undesirable. In situations such as these, the medical laboratory tutor will be responsible for directing the education and training at both the basic science and applied levels. Assistance in teaching the basic science subjects may be sought from chemistry, physics and biology teachers in local secondary schools or from the nearest university or college. There are, however, problems in employing part-time teachers for this function; the course may become disjointed; it may get off to a bad start, with the lecturers failing to teach at the correct level, so that the students become dispirited and disinterested; attention to course records, homework, and marking of practical books may be deficient; the mounting of basic science practical classes may create problems for the medical laboratory tutor who is faced with the problem of providing, servicing and setting out apparatus and reagents with which he is not completely familiar.

On rare occasions it may be necessary to employ, as part-time teachers, scientists who are not practising educationists. This situation possesses all the difficulties already mentioned and more besides. All these circumstances make the tutor's job the more difficult and responsible, but the fact remains that he must direct the course, coordinate it and evaluate it at every stage to check that the objectives are being achieved.

OTHER DUTIES OF A TUTOR

Training duties

Apart from his lecturing and teaching duties, it will be the tutor's job to instruct the technician in the skills of medical laboratory practice, in the performance of routine methods. His first task, therefore, will be to prepare a detailed analysis of the tasks the technician will be required to perform. As early as possible, the student should be introduced to the real-life situation in the laboratory and should be allowed actually to perform the tests in which he has already been instructed. If he is being introduced to a blood sugar estimative technique, he should be allowed to perform the test on a number of samples which have already been discarded by the routine laboratory and his results should be compared with those produced by his more experienced colleagues. It may be the tutor's job to cooperate with his technician colleagues to produce specimens offering high and low blood sugar levels. (It is always useful to include the same sample twice and show the student any discrepancies between the two results.) As the student's results become more and more comparable with the results already obtained, less and less supervision will be required, until he reaches the point where he is capable of being included in the laboratory team. Throughout this process, the tutor is gradually handing over the supervision to his medical laboratory colleagues.

The tutor will be responsible for keeping a detailed list of techniques and methods which the student should be capable of performing. As the student reaches a level of competence in each of these techniques, a permanent record should be kept of his progress. Where possible, the student himself should be encouraged by the tutor to keep a record of both completed and uncompleted techniques. Some training centres have issued their students with a booklet in which are listed all the techniques to be learned. As each task is completed, the tutor marks the student's booklet accordingly.

Record keeping

A regular comment should be made on the student's record of his progress, his aptitudes and his interest. For example, some technicians show a real interest in the mechanics and electronics of various instruments. It is worth making a relevant observation on their record. The same record should include observations made at the selection interview, along with the student's school attainments and details of any competitive theoretical and practical tests used for selection. In this way it may be possible to trace the reason for failure in any individual student. If events show that the student was wrongly selected in the first place, it may be possible to trace a common factor between that student and other previous failures and thus improve the selection process.

The record should also carry details of the student's attainments during his college course, the observations of senior technicians during his training, and other vital information needful in the overall process of objectively assessing the student's progress and potential. The record should show details of attendance at courses, homework marks, practical marks and continuous assessment marks in all the subjects studied.

It is easy to neglect this aspect of the tutor's functions, or in busy periods to allow the record keeping to fall behind. A period should be set aside every week without fail for the completion of the task. From time to time it will be necessary to make such records available to the director of the laboratory, the hospital administration or professional bodies, such as registration boards.

Committee duties

It must be obvious that to do his job efficiently the tutor should be involved in committees responsible for the selection of new staff. Committees responsible for laboratory planning and development should include the tutor. His will be the responsibility of identifying new areas of training needed and planning the appropriate action.

Organization of library facilities

No matter how limited the supply of textbooks and reference works may be, an effort should be made in the laboratory to organize and encourage their use. If it is seen that the laboratory values its books and journals, then technicians at all levels will come to use the library frequently. In most cases funds for the establishment of the library will be limited. The tutor should endeavour to acquaint himself with book reviews when selecting the books and also write to publishers and encourage them to send him literature and, where possible, specimen copies of their books. He should ensure that the books available adequately cover the interests represented in the laboratory.

All levels of staff should be encouraged to read what journals are available and "journal clubs" should be arranged at which the articles may be discussed in relation to the work of the laboratory. Where a large number of journals are available they should be distributed among the staff, who will then be responsible for presenting a summary of appropriate articles at the meeting of the "journal club". These summaries should be kept and cross-referenced by the tutor, and their use encouraged.

Organization of seminars

From time to time the tutor should encourage various senior members of the laboratory staff to present short papers to their colleagues.

Counselling

In most cases the tutor will be unaware of the personal difficulties to which his students are being subjected. A student's performance will be affected by his personal happiness and contentment which, in turn, will be influenced by his relationships within his working situation and outside the hospital in his private life. The tutor should encourage a suitable relationship between himself and each individual student so that the student will learn to confide in him and accept his counsel by virtue of his sound experience and his sympathetic and patient attitude.

Responsibility for safety

To maintain a safe working environment in the laboratory requires the designation of a "safety officer" whose task is to establish a constant vigil over all laboratory practice and continually to remind all levels of staff of the need for safety. Furthermore, there should be a well-organized and strenuous effort to introduce "safety awareness" at an early stage in the student technician's career. An appropriate individual able to combine these functions would be the medical laboratory tutor.

Undoubtedly, the topic of "safety in the laboratory" needs to be introduced into the curriculum as a specific topic and also throughout the course at the appropriate points. (For this reason, brief details of the topic have been included in Annex 6.)

THE TRAINING OF THE TUTOR

It is well known that an advanced knowledge of a subject in no way ensures the ability to impart that knowledge. Experts in any subject operating as untrained teachers are frequently guilty of monotonous delivery, hurried style, dictated lectures, inaudibility, and other characteristics guaranteed to hinder the learning process. Regrettably, the expert is all too often unaware of his inadequacies as a teacher.

Even the most inspired medical laboratory tutor will require a period of formal instruction and training in the methodology of teaching. This training should include periods of actual teaching practice, supervised by an education tutor. In this way, the abilities of the individual will be improved while he learns to marshal the available resources and to make the best use of the learning opportunity.

After attendance at an appropriate training course the tutor should serve a probationary period, during which time he is assessing his own aptitude and enthusiasm for teaching and seeking to evaluate his new function by comparison with his former job as a practising technician. The probationary period would also be a time during which the hospital or medical centre would have the opportunity of assessing the tutor's ability and suitability and also giving consideration to the tutor's potential after further experience.

A good teacher never ceases to learn, so that for the medical laboratory tutor his training should be an ongoing experience. His medical laboratory colleagues are able to stimulate and enrich each other's experience, but there will be a sense in which the tutor is isolated from others who are performing the same job, facing the same problems and seeking to develop the same area of new ground. It will be necessary, therefore, for him to meet his colleagues from other laboratories in order to exchange experiences and ideas.

Where it is not possible to arrange conferences or courses to meet the need, an association of tutors should be formed in different areas to facilitate the interchange of names and addresses of likeminded individuals and possibly initiate some form of publication directly concerned with problems and developments associated with the teaching of medical laboratory technology. Such an association could publish the titles of films made freely available for teaching by the large pharmaceutical companies, as well as other teaching aids such as charts, slides, programmed learning texts and teaching kits. It is often a problem in teaching medical technology, to obtain suitable pathological material, which always appears to be in short supply at the point in the syllabus at which it is most needed. The association could be of real help in establishing cooperation between tutors in matters of this nature.

In all, the medical laboratory tutor's job will be a highly responsible function, demanding real enthusiasm, effort and a professional approach. The influence of his character and work will be reflected in the efficiency of the laboratory.

FURTHER READING

Russell, G. J., Teaching in Further Education. Pitman Education Library, London.

ANNEX 1. THE FUNCTIONS AND RESPONSIBILITIES OF VARIOUS CATEGORIES OF TECHNICAL LABORATORY PERSONNEL

Any course of training and education will remain inadequate or inappropriate in the absence of clear objectives. These in turn will be dependent upon complete job and task analyses. The following detailed description of the functions and responsibilities of each grade of technical laboratory staff is to be found in the WHO Technical Report Series, No. 345, 1966, and tutors are recommended to refer to that report.

Graduate Technician (level A)

Basic functions:	(a) Supervision of other technical personnel (levels B, C and D) and laboratory aides. (b) Administrative duties assigned by the director of the laboratory.
Scope:	This job is concerned with technical teaching and administrative responsibilities. The incumbent is required to ensure that all procedures and regulations established by the director are followed by all staff supervised. The incumbent should be able to recognize and correct errors and defects that may occur in routine work under his supervision.
Detailed functions:	(a) Immediate supervision of subordinate staff. (b) Participation in the setting up of new or approved procedures, with the approval of the director. (c) Performance of standard or special tests. (d) Preparation of special standards and reagents and control of those prepared by subordinates. (e) Training of subordinates and students. (f) Assisting medical and scientific staff in laboratory teaching. (g) Preparation of periodic reports of activity and maintenance of inventory of stocks. (h) Performance of other technical work or related duties as assigned. (i) Participation in research work as assigned.
Supervision received:	From medical and scientific staff.
Supervisory responsibilities:	Administrative and technical supervision of subordinate personnel; exercises considerable initiative and judgement in supervising his area and in establishing new procedures.

Annex 1

Non-graduate Certified Technician (level B)

Basic functions: (a) Performance of all routine and some special laboratory procedures.

(b) Assisting in the training and supervision of subordinate technical personnel.

(c) Assisting in teaching.

Scope: This job is primarily concerned with either

(a) the performance of routine laboratory work, the exact nature of which is determined by the laboratory discipline in which the incumbent is employed and by the type of work in progress,

or

(b) the preparation of specimens and reagents needed by laboratory course work, the maintenance of equipment and stocks used, and the setting-up of the necessary apparatus.

Detailed functions: (a) Collection of such specimens as he is trained to collect and as local traditions and regulations permit.

(b) Performance of standard laboratory procedures as assigned.

If the incumbent is assigned to a teaching laboratory he has to have this ready for course work (lectures and laboratories) and to provide the faculty and students with the supplies and materials they need for their work.

(c) Preparation and testing of reagents and media.

(d) Preparation of simple standards, solutions, suspensions, etc.

(e) Operation, cleansing and maintenance of equipment.

(f) Performance of any other technical work assigned.

(g) Submission of reports of all results and keeping of records of all procedures performed and results obtained.

(h) Requisition of supplies and maintenance of inventory of same, where required. Maintenance of stock inventory.

Supervision received: From medical and scientific staff and graduate technician.

Supervisory responsibilities: Supervision of assistant technicians (levels C and D) and laboratory aides.

Annex 1

Certified-assistant Technician (level C)

Basic functions: (a) Accurate repetition of well established laboratory procedures.

(b) Carrying out of detailed written instructions.

(c) Operation and reading of recording instruments, accurate calculation of results, reporting of data.

(d) Performance of the necessary clerical work.

Scope: This job is concerned with the performance of well defined standard routine tests as well as helping in preparing teaching material where a teaching programme exists.

Detailed functions: (a) Carrying out of standard procedures (chemical, biological, etc.) as assigned.

(b) Operation of equipment and instruments needed for the job.

(c) Recording and reporting of results.

Supervision received: From technicians at levels A and B

Supervisory responsibilities: When required by special circumstances, responsibility for supervision of technicians at level D and laboratory aides may be assigned.

Non-certified Assistant Technician (level D)

Basic functions: Assisting in the performance of technical duties.

Scope: Performance of the simpler routine laboratory procedures.

Detailed functions: (a) Performance of simple laboratory analyses and procedures such as routine urinalysis, preparation of smears, simple staining techniques, etc. and assistance in the preparation of simple reagents and media.

(b) Operation of instruments and apparatus and accurate recording of results.

(c) Care of equipment used.

Supervision received: From technicians at levels A, B and possibly C.

Supervisory responsibilities: None (except supervision of laboratory aides).

Note: Workers who have been trained to perform a single-skill technique and who are employed in field work, such as blood-smear examination in malaria eradication campaigns, are classified in this group.

ANNEX 2. PLANNING THE TRAINING OF MEDICAL LABORATORY TECHNICIANS

GENERAL OBSERVATIONS

Technicians will learn whether or not their training is planned. However, the tutor must ask himself whether the technicians in his laboratory are learning the right things, at the right time, in the best way, and at an economic cost, and whether they are being helped to put what they learn into practice. Training is an investment in people; it must be closely related to the needs of the laboratory and not left to chance.

Growth and change make new demands on laboratory staff. It is always necessary to equip new staff with skills, knowledge and attitudes to meet the new demands.

Systematic training involves 3 phases: (i) planning - ensuring that relevant and economic training is prepared for; (ii) implementing - carrying out the training that has been planned; ~~and (iii)~~ reviewing - ensuring that the planned training has been carried out, that it has achieved its purpose and has been worth while and that the experience gained is fed back to modify and improve future plans.

SPECIFYING THE TRAINING POLICY

The hospital or medical centre should give an explicit statement of the part its intended training will play in the laboratory programme and the students' experience. This statement acts as a basis by: elucidating the hospital's attitude to the training of its technicians; making known how the responsibilities for training will be apportioned within the laboratory; describing the resources that the hospital or medical centre intends to allocate to training in terms of both staff and finance; and communicating the hospital's training policy to all levels of staff.

IDENTIFYING THE AREAS WHERE A TRAINING NEED EXISTS

A training need exists when technicians lack the skills or knowledge required for their present function, or for their future role.

Quality control techniques may indicate that the technicians' performance is not up to the standards required for their present function. On the other hand their techniques may be accurate but they may be dangerous to themselves or their colleagues because of inadequate attention to safety procedures.

Where their skills or knowledge are inadequate for their future role they will require training in improved techniques replacing present practices.

Identifying a training need is a dynamic process. In practice, training needs are continually occurring among all levels of laboratory personnel.

How to assess the present training need

(1) List all staff in the laboratory in terms of categories, numbers, and where they may be located (e.g., division of laboratory or satellite laboratory).

(2) State how they fit into the organization of your health laboratory service (divisions, lines of authority).

(3) State their individual functions (in terms of job titles, job descriptions, and responsibilities).

(4) List the problems that exist at present and why they are thought to occur. (The list should include comments on adequacy of present technical performance, deficiency in management skills, unsuitable staff recruitment, etc.)

How to assess future training needs

(1) List the foreseeable developments that are likely to take place in your health laboratory service (e.g., developments in diagnostic tests, the laboratory control of new therapeutic measures, preventive medicine exercises, cervical cytology, etc.). The list should include reference to plans for laboratory expansion, reorganizations, and new government or professional body legislation.

(2) List the new staff that will be required, in terms of numbers and categories and taking into account normal growth, staff promotions and staff turnover.

(3) Consider how you can develop the abilities, interests and skills of all levels of existing staff, and how you can improve their potential.

How to match the present training practice to present and future needs

(1) Specify the current training - induction courses, training for present jobs.

(2) Specify the training methods - "On the job" or "Off the job".

(3) Estimate the effectiveness of the training in terms of results. Have you sought the opinions of pathologists and senior technical staff? Have opinions been expressed as to quality, reliability and productivity? Is there staff satisfaction? Do the staff who have completed the present training programme feel that it was adequate or that it could be improved?

(4) Estimate the cost by considering the salary of the trainer, the salary of the student throughout the training period, the materials needed in training, and the depreciation on apparatus. Consider whether economies can be effected by reducing the training period with concomitant improvement in training techniques, or by other means.

(5) Match the needs to the practice. Does the training match the estimated needs in terms of quantity (i.e., Is it supplying the required number of laboratory staff?) and quality (i.e., Is it supplying the laboratory service with the right calibre and expertise?). Are there any major and obvious deficiencies?

A possible outcome of a survey of this nature will be that certain factors will be highlighted which directly affect the training of the technicians, but over which the tutor may have no control. For instance, present manpower planning may be inadequate; there may be a need for more care in recruitment and for improving student selection techniques; the organization of the laboratory may require improvement so that the student will always be able to attend each training session; the techniques used in the laboratory may be beyond the capabilities of the student technicians; or the equipment and apparatus in the laboratory may need improving.

Decisions on training may be affected by the results of decisions on these other problems.

Questions for discussion: (1) Do you regularly review your training needs in a systematic way? (2) Are you overlooking any relevant factors in identifying the training needs? (3) Have you considered what factors are preventing your technicians from using the skills and knowledge gained during the training period?

PREPARING THE TRAINING PLAN

The tutor should prepare a document which clearly shows the training to which the health laboratory service intends to commit itself over a given period of time. It may be a simple outline or a comprehensive plan covering all aspects of the laboratory.

It should not only include details of the areas of pathology to be covered but also make reference to important topics such as instruction in quality control, safety in the laboratory, laboratory management techniques, laboratory communications, etc. - all key areas which affect specific categories of laboratory staff.

If it is to lead to effective training action, the training plan will need to specify: (i) the period covered by the plan; (ii) the resources to be allocated specifically to training; (iii) the categories of laboratory staff to be trained during the period specified by the plan; (iv) the type of training experience to which each category will be subjected (e.g., new students and induction training, senior technicians and management techniques, automated analytical techniques for experienced staff in chemical pathology units); (v) the duration of the training and its form (e.g., 2 weeks "on the job" training); and (vi) the individual having the overall responsibility of organizing and effecting the training.

IMPLEMENTING THE TRAINING SCHEME

(1) Inform all levels of staff involved - students, senior technical staff, tutors - of the training plans and detailed schemes.

(2) Specify the results expected in terms of objectives - what those who are to be trained will know and be able to do at the end of the training period.

(3) Detail the training venue - where and when.

(4) Detail the subject matter to be covered at each individual session.

(5) State the method to be used (practical instruction, lecture, film, etc.).

(6) Specify who will be responsible for each individual session.

(7) State how the training will be followed up and reviewed, i.e. practical tests as assessment; discussion with those who have completed the training; follow-up support and coaching from laboratory supervisors; assessment of improved performance from time to time.

No plan will be perfect. Invite the criticism of students and colleagues and assess the scheme critically for yourself.

ANNEX 3. DETAILED PLANNING OF A TRAINING PROGRAMME FOR MEDICAL LABORATORY TECHNICIANS

A vital step in any training programme is to analyse the nature of the job and tasks involved.

When we talk about a "job" we are referring to all the tasks carried out by a particular technician in the completion of his prescribed duties. (In a wider context, the term may also cover the physical and social environment in which the technician is expected to perform his duties.)

A job, then, is made up of a series of duties.

Illustration:

If the function of a level C certified assistant technician is that of "medical laboratory technology", then his duties will include:

- duty 1 - carrying out standard laboratory procedures
- duty 2 - recording and reporting results
- duty 3 - supervision of non-certified assistant technicians (level D)

In turn, each duty may be subdivided into separate tasks. (For example, duty 1 involves many different tests - which constitute tasks.)

Let us define "task".

A task is a major element of work or a combination of elements of work by means of which a specific result is achieved.

But a task may be broken down further into task elements. For example, if the task is a haemoglobin estimation, then the task elements will involve (i) taking the specimen, (ii) making the dilution of blood, (iii) estimating the concentration of haemoglobin in the blood dilution in some appropriate apparatus and calculating the result.

If necessary, we may reduce the task elements even further by examining the acts. The acts consist of details of skills required to take the blood, the individual skills required to make accurate dilutions, the skill needed to use the apparatus, the skill needed to make the calculation.

Each level - duty, task, task element, act - describes the job in successively greater detail.

At the highest level there is the job itself. At the lowest level - the single act or skill.

The difference between the task and the duty is not hard and fast - the person doing the analysis must decide for himself.

JOB ANALYSIS

Before starting a training programme, a tutor must do a "job analysis".

This is the process of examining a job in order to identify its component parts and the circumstances in which it is performed. A job analysis may give rise to at least three pieces of information: (i) job description; (ii) job specification; (iii) task analysis.

Job description

This is a broad statement of the purpose, scope, and responsibilities of a particular job. It is used for organizational purposes and possibly for informing prospective students. It includes the following elements:

Annex 3

Job Description of level-C Technician (Bacteriology)

Title

Departments - Bacteriology (or all departments)

Function - to perform standard laboratory procedures accurately and record the results

Hours of work

Emergency duties

Responsible to:

Responsible for:

Duties (in broad terms)

1. Comply with the rules and practices of the laboratory at all times.
2. Carry out standard bacteriological (clinical chemistry, haematology) procedures.
3. Operate equipment.

(Other duties may be added according to the requirement)

Job specification

This is another product of job analysis - a detailed statement of the physical and mental activities involved in the job and, when relevant, of social and physical environmental matters. The specification is usually expressed in terms of behaviour i.e. what the worker does, what knowledge he uses in doing it, the judgements he makes and the factors he takes into account when making them. Basically, the job specification specifies the skills and knowledge required to carry out the tasks which form the duties involved in the occupation.

In the job specification the duties and associated tasks should be listed in the same order as the job description. Three columns are listed:

Knowledge. A knowledge item is simply something which the person carrying out a particular task must know.

Skills (only a simple definition). A skill at its simplest level is an act (or series of acts) that requires practice in order to perform it adequately. (At a more complex level, skills may be classified as perceptual, motor, manual, intellectual.)

Social skills. These involve contact with other people - the ability to cooperate with fellow technicians and to handle patients - attitudes to senior staff, etc.

Example of Job Specification

Duties or tasks	Knowledge	Skills	Social skills
Estimating patients' haemoglobin, using capillary blood.	Principles of asceptic technique. Preparation of haemoglobin standard. Use of colorimeter. Formula for calculation.	Accuracy in blood sampling. Use of pipette. Sensitivity in handling colorimeter controls.	Ability to communicate with patient and handle gently.

To perform his task with clear objectives the medical laboratory tutor will need to break down the functions of the technician he is to teach into small details by way of job analysis and task analysis.

Annex 3

Performing a job analysis

We have looked at what a job analysis is and how it may be presented. Now let us consider how we can go about preparing this job analysis in order to obtain a job specification.

(1) Establish the relationship of the job to the system. Describe and analyse the system within which the job is performed. Efforts should be made to study the management system in so far as it affects the job and the interpersonal relationships involved. Exercise (1): List the jobs of different individuals with whom the technician may come into contact during his working day. Exercise (2): List the management structure affecting the technician.

(2) Identify the "job master". Select as job master a qualified and competent technician. Carry out a careful analysis of the job by observing the job master at work, list his duties and tasks. The job master must be observed in his normal place of work and under normal working conditions. When the analysis of his job has been completed, it should be checked (i) with the job master himself, in case there have been any omissions, and (ii) with the individual to whom the job master is responsible, to ensure that his actions and standards are acceptable.

Job analysis involves a great deal of watching and questioning of the persons doing the job which is being analysed. The individual performing the analysis will need to use great tact and he must realize that his presence will have some effect on the job master and his performance.

(3) Make only brief notes so as not to distract your own attention too much from the task. Remember that you cannot expect the job master to keep stopping and answering questions all the time.

TASK ANALYSIS

This is a systematic analysis ~~of the beha~~viour required to carry out a task, made with a view to identifying areas of difficulty and then selecting the appropriate training techniques and learning aids necessary for successful instruction.

Once each duty has been defined it must ultimately be broken down into its smallest constituent parts - tasks, task elements and acts. This may seem a lengthy and laborious process. It will entail a great deal of time and may seem to involve going into too much unnecessary detail. However, it must be stressed that analysis is essential if intelligent decisions are to be made.

Thus, the term "task analysis" is used to describe what is in fact the analysis of an item identified as a skill in the job specification - before we can teach that skill we must analyse it carefully.

Let us go back to the first skill mentioned in our job specification - "Accuracy in blood sampling from a patient" - and consider how we can teach it.

I think we should break it down into "stages", "steps" and "safety and other factors".

Each stage is a major or obvious break point in the operation. Basically it describes what must be done. A simple skill may involve only one stage, whilst more complex ones could be comprised of any number.

In the steps column we write the detail necessary to show how the skilled task is done (again there may be any number of steps in a given stage).

The third column, "Safety and other factors" includes safety points, reasons, standards and other important relevant information.

Annex 3

Let us take an example from the previously illustrated job specification and break down the task in terms of the skill required to take an accurate blood sample from a patient, using a capillary blood technique.

Stages	Steps	Safety and other factors
Prepare patient's ear lobe (or finger, etc.).	Warm lobe with gentle rubbing. Asceptically remove sterile swab from container and clean patient's ear lobe with 75% alcohol. Wait for sterilizing agent to dry.	Care in not contaminating the swab.
Pierce patient's ear lobe.	Remove sterile needle asceptically from container. Hold ear lobe between finger and thumb. Pierce to depth of 2 mm.	Previously used needles may cause infective hepatitis.
Sample patient's blood.	Wait for blood to flow freely. Wipe away first drop of blood. etc.	Inaccuracy due to presence of tissue juice.

The above is only one of many ways in which a task analysis may be presented, and is used for comparatively simple activities. It highlights areas of difficulty and shows what the technician must learn in order to achieve a satisfactory level of performance.

The tutor making an analysis must always be making a decision on how much detail is required. Clearly, the greater the degree of detail, the more the work involved.

Job analysis is only a means to an end. It is intended to produce effective and efficient training. There is no merit in producing extremely detailed documents which look impressive but do nothing useful. The tutor will learn, therefore, by experience how much detail he must go into.

Three factors will help in deciding how much detail is necessary: (i) the degree of difficulty - the more difficult the task, the more detail will be required; (ii) the ability of the student to learn and his previous experience in doing the task; and (iii) the degree of importance of the task, the responsibility involved, and possible dangers.

ANNEX 4. A PROPOSED PROGRAMME FOR TRAINING

GENERAL TRAINING

	Theory	Practical	Comments
Induction:			
Conditions of employment	....	....	....
The technician and his relationship to the hospital as a whole	....	....	....
Tour of hospital compound	....	....	....
Social amenities	....	....	....
The technician's career and training. The nature of the educational courses he will undertake.	....	....	....
Basic first aid	....	....	....
Basic fire drill	....	....	....
Basic personal safety	....	....	....
Basic ethics	....	....	....

Annex 4

BACTERIOLOGY

	Theory	Practical	Comments
Receipt and recording of specimens	....	....	....
Personal safety precautions	....	....	....
Emergency treatment for accidents	....	....	....
Care and cleaning of glassware, syringes, and apparatus	....	....	....
Operation of:			
(a) water baths	....	....	....
(b) incubators	....	....	....
(c) hot-air ovens	....	....	....
(d) autoclaves	....	....	....
Preparation of filters:			
(a) asbestos	....	....	....
(b) sintered glass	....	....	....
(c) membrane	....	....	....
(d) Buchner	....	....	....
Handling and disposal of infected material	....	....	....
Preparation of specimen containers:			
(a) blood counts	....	....	....
(b) blood sugar	....	....	....
(c) blood, oxalated	....	....	....
(d) electrolytes	....	....	....
(e) throat swabs	....	....	....
(f) prenasal swabs	....	....	....
(g) postnasal swabs	....	....	....
(h) prothrombin bottles	....	....	....
(i) faeces containers	....	....	....
Sterilization by:			
(a) steam	....	....	....
(b) dry heat	....	....	....
(c) red heat	....	....	....
(d) boiling	....	....	....
(e) filtration	....	....	....
(f) chemical methods	....	....	....

Annex 4

Bacteriology - continued	Theory	Practical	Comments
Manipulation and care of the microscope	....	....	....
Simple glass manipulation	....	....	....
Preparation of films of clinical material	....	....	....
Wet preparations and motility	....	....	....
Recognition in urine of:			
(a) erythrocytes	....	....	....
(b) leucocytes	....	....	....
(c) casts	....	....	....
(d) bacteria	....	....	....
Recognition in faeces of:			
(a) starch	....	....	....
(b) muscle fibre	....	....	....
Constituents and method of preparing:			
(a) Gram's stain	....	....	....
(b) Ziehl-Neelsen	....	....	....
(c) Stain for corynebacteria	....	....	....
(d) Methylene blue	....	....	....
The use of:			
(a) Gram's stain and modifications	....	....	....
(b) Ziehl-Neelsen	....	....	....
Reaction of more common organisms to Gram's stain	....	....	....
Cultural appearance of more common organisms	....	....	....
Microscopic appearance of more common organisms	....	....	....
Inoculation of:			
(a) Plate cultures	....	....	....
(b) Slope cultures	....	....	....
(c) Stab cultures	....	....	....
(d) Shake cultures	....	....	....
(e) Preparation of pure cultures	....	....	....
Aerobic culture method	....	....	....
Anaerobic culture methods	....	....	....

Bacteriology - continued	Theory	Practical	Comments
Carbon dioxide culture methods	....	....	....
Use of wire loops and spreaders	....	....	....
Sensitivity tests	....	....	....
Dilution methods:			
(a) doubling dilutions	....	....	....
(b) serial dilutions	....	....	....
(c) progressive dilutions	....	....	....
(d) dropping pipettes	....	....	....
Tube methods for detecting antibodies	....	....	....
Slide methods for detecting antibodies	....	....	....
Tube method for coagulase test for staphylococci	....	....	....
Slide method for coagulase test for staphylococci	....	....	....
Care of laboratory animals	....	....	....
Cage sterilization	....	....	....
Killing of animals	....	....	....
Preparing animals for post mortem	....	....	....
Holding animals for inoculation	....	....	....
Disposal of cadaver and other wastes	....	....	....
Essential requirements of culture media	....	....	....
Constituents, preparation and use of media including:			
(a) nutrient broth	....	....	....
(b) nutrient agar	....	....	....
(c) digest broth	....	....	....
(d) blood agar	....	....	....
(e) chocolate agar	....	....	....
(f) nutrient gelatine	....	....	....
(g) McConkey's medium	....	....	....
(h) desoxycholate citrate medium	....	....	....
(i) peptone water	....	....	....
(j) peptone water sugars	....	....	....
(k) Hiss's serum water sugar	....	....	....

Annex 4

Bacteriology - continued	Theory	Practical	Comments
(l) Löffler's inspissated serum	....	....	....
(m) Löwenstein's medium	....	....	....
(n) Dorset's egg medium	....	....	....
(o) cooked meat broth	....	....	....
(p) Brewer's medium	....	....	....
(q) Hoyle's medium	....	....	....
(r) Wilson and Blair's medium	....	....	....
(s) blood culture media	....	....	....
(t) Sabouraud's media	....	....	....
(u) transport media	....	....	....
Preparation of single plates of media	....	....	....
Colorimetric method of estimating and adjusting pH	....	....	....

Additional experience:

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Annex 4

CHEMICAL PATHOLOGY

	Theory	Practical	Comments
Reception and recording of specimens	....	....	....
Production and storage of distilled and deionized water	....	....	....
Principles, use and maintenance of:			
(a) water baths	....	....	....
(b) gas cylinders and valves	....	....	....
(c) centrifuges	....	....	....
(d) absorptiometers	....	....	....
(e) spectroscopes	....	....	....
(f) autoanalysers	....	....	....
(g) balances	....	....	....
(h) Venturi pumps	....	....	....
(i) Buchner funnels	....	....	....
(j) hydrometers	....	....	....
(k) pipettes and graduated apparatus	....	....	....
(l) pH meters	....	....	....
(m) flame photometers	....	....	....
Storage of dangerous compounds	....	....	....
Safety precautions and emergency treatment for accidents	....	....	....
Preservatives and anticoagulants	....	....	....
Separation of serum and plasma	....	....	....
Techniques in the examination of:			
(1) FAECES:			
(a) occult blood	....	....	....
(b) trypsin	....	....	....
(c) urobilin	....	....	....
(d) bile	....	....	....
(2) CEREBROSPINAL FLUID:			
(a) appearance	....	....	....
(b) chloride	....	....	....
(c) glucose	....	....	....

Annex 4

Chemical pathology - continued	Theory	Practical	Comments
(d) protein	....	....	....
(e) globulin	....	....	....
(3) URINE:			
(a) appearance	....	....	....
(b) specific gravity	....	....	....
(c) pH	....	....	....
(d) protein:			
boiling test	....	....	....
sulfosalicylic acid test	....	....	....
nitric acid test	....	....	....
biuret test	....	....	....
dipstick test	....	....	....
tests for Bence Jones protein	....	....	....
test for mucus	....	....	....
(e) ketones:			
Rothera's test	....	....	....
Gerhardt's test	....	....	....
test for salicylates	....	....	....
dipstick and tablet tests	....	....	....
(f) bile pigments:			
Fouchet's test	....	....	....
Gmelin's test	....	....	....
dipstick test	....	....	....
(g) bile salts	....	....	....
(h) urobilinogen	....	....	....
(i) urobilin	....	....	....
(j) blood:			
chemical	....	....	....
spectroscopic	....	....	....
(k) detection and identification of reducing substances:			
Benedict's method	....	....	....
yeast fermentation	....	....	....
glucose oxidase	....	....	....
osazone test	....	....	....
Selivanoff's test	....	....	....
methylamine test	....	....	....

Annex 4

Chemical pathology - continued	Theory	Practical	Comments
Bial's test	....	....	....
mucic acid test	....	....	....
Tollens' test	....	....	....
(1) chromatography of sugars	....	....	....
Quantitative estimation of:			
(a) amylase	....	....	....
(b) urea	....	....	....
(c) chloride	....	....	....
(d) glucose	....	....	....
(e) protein	....	....	....
(4) BLOOD:			
Quantitative estimation of:			
(a) urea	....	....	....
(b) glucose	....	....	....
(5) GASTRIC JUICE:			
Titration of "free" and "total" acid	....	....	....

Additional experience:

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Annex 4

HISTOPATHOLOGY

	Theory	Practical	Comments
The purpose of histopathological examination	....	....	....
Recording and identifying specimens	....	....	....
Fixation of gross specimens:			
(a) formal saline	....	....	....
(b) Kaiserling's fluid	....	....	....
Selection of tissue blocks	....	....	....
Principles of fixation:			
(a) formal sublimate	....	....	....
(b) Helly's fluid	....	....	....
(c) Zenker's fluid	....	....	....
(d) Bouin's fluid	....	....	....
(e) Carnoy's fluid	....	....	....
Treatment of fixed material	....	....	....
Decalcification	....	....	....
Removal of fixation pigments from slides	....	....	....
Preparation and fixation of smears	....	....	....
Dehydration	....	....	....
Dealcoholizing methods	....	....	....
Wax impregnation	....	....	....
Properties of a good wax	....	....	....
Automatic processing	....	....	....
Rapid hand processing	....	....	....
Embedding methods	....	....	....
Block preparation by hand	....	....	....
Microtomy	....	....	....
Sharpening and care of microtome knives	....	....	....
Section faults and their correction	....	....	....
Attachment of sections to slides	....	....	....

Annex 4

Histopathology - continued	Theory	Practical	Comments
The importance of drying sections	....	....	....
Principles of staining:			
(a) dye structure	....	....	....
(b) tissue structure	....	....	....
(c) use of mordants	....	....	....
Staining methods:			
(a) haematoxylin eosin	....	....	....
(b) Heidenhain's iron haematoxylin	....	....	....
(c) Weigert's iron haematoxylin and van Gieson's stain	....	....	....
(d) Verhoeff's method for elastic tissue	....	....	....
(e) Prussian blue	....	....	....
(f) mucicarmine	....	....	....
(g) Ziehl-Neelsen stain	....	....	....
(h) Gram's stain	....	....	....
(i) Papanicolaou's stain	....	....	....
Mountants for stained sections	....	....	....
Storage of slides	....	....	....
Freezing microtome:			
(a) rapid technique	....	....	....
(b) fat stains	....	....	....
(c) other techniques	....	....	....
Recognition of tissues	....	....	....
Disposal of waste tissues	....	....	....
Microscopy:			
(a) principles and practice	....	....	....
(b) critical illumination	....	....	....
(c) micrometry	....	....	....
Additional experience:			
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Annex 4

HAEMATOLOGY

	Theory	Practical	Comments
Use, care, and cleaning of glassware	....	....	....
Reception and recording of specimens - documentation	....	....	....
Storage and handling of dangerous compounds	....	....	....
Principles, maintenance, and use of:			
(a) water baths	....	....	....
(b) refrigerators	....	....	....
(c) incubators	....	....	....
(d) colorimeters	....	....	....
(e) electronic equipment	....	....	....
(f) automation apparatus	....	....	....
(g) filtration equipment	....	....	....
Manipulation, care, and use of microscope	....	....	....
Simple glass manipulation	....	....	....
Preparation of diluting fluids and reagents	....	....	....
Composition and preparation of Romanowsky stains	....	....	....
Use of Romanowsky stains	....	....	....
Preparation and staining of blood films	....	....	....
Recognition of normal types of leucocytes in blood	....	....	....
Recognition of simple morphological changes in erythrocytes	....	....	....
Visual counting of:			
(a) erythrocytes	....	....	....
(b) leucocytes	....	....	....
(c) reticulocytes	....	....	....
(d) platelets	....	....	....
Haemoglobin screening by specific gravity techniques	....	....	....
Haemoglobin estimation by commonly used procedures	....	....	....

Annex 4

Haematology - continued	Theory	Practical	Comments
Derivation and use of:			
(a) colour index	....	....	....
(b) packed cell volume	....	....	....
(c) mean corpuscular volume	....	....	....
(d) mean corpuscular haemoglobin concentration	....	....	....
(e) mean corpuscular haemoglobin	....	....	....
Estimation of erythrocyte sedimentation rate	....	....	....
Osmotic fragility tests	....	....	....
Bleeding time techniques	....	....	....
Clotting time techniques	....	....	....
"One stage" prothrombin	....	....	....
"Thrombotest"	....	....	....
Preparation and mode of action of common anticoagulants used in:			
(a) haematology	....	....	....
(b) blood transfusion	....	....	....
Additional experience:			
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Annex 4

BLOOD TRANSFUSION

	Theory	Practical	Comments
Sources of clerical errors and prevention - documentation	....	....	....
Methods of ABO grouping (including A_2)	....	....	....
Causes of inaccuracy	....	....	....
The use and reason for controls	....	....	....
Selection and testing of grouping sera (human and lectin)	....	....	....
Methods of detecting presence of D antigen	....	....	....
Detection of complete and incomplete D antibody:			
(a) saline	....	....	....
(b) albumin	....	....	....
(c) antiglobulin techniques, including preparation and standardization of reagent	....	....	....
(d) enzymes	....	....	....
Titration of D antibody:			
(a) saline	....	....	....
(b) albumin	....	....	....
General care and organization of blood banks	....	....	....
Preparation of pyrogen-free distilled water	....	....	....
Conditions for storage of:			
(a) blood	....	....	....
(b) plasma	....	....	....
(c) plasma substitutes	....	....	....
(d) blood substitutes	....	....	....
Criteria of fitness for use of the above	....	....	....
Preparation of pooled plasma	....	....	....
Concentration of erythrocyte suspensions	....	....	....

Annex 4

Blood transfusion — continued	Theory	Practical	Comments
Washing and/or resuspension of concentrated erythrocytes	....	....	....
Cleaning and preparation of taking sets	....	....	....
Sharpening of needles	....	....	....
Maintenance of blood bank records	....	....	....
Methods for transport of blood	....	....	....
Additional experience:			
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ANNEX 5. AN EXAMPLE OF A PROGRAMMED LEARNING SCHEME[1]

INSTRUCTIONS TO STUDENTS

Cover all questions (with a large piece of paper) so that only question 1 is in view. Fill in the blank space with what you consider to be the appropriate word.

Now move your paper so that frame 2 is exposed. The answer to frame 1 is in the top left-hand corner of frame 2. Continue in the same way with each succeeding question.

PROGRAMMED LEARNING ON ANTICOAGULANTS

1. The word anticoagulant means against clotting. An a__________ is therefore a substance which stops the c__________ of blood.

ANTICOAGULANT
CLOTTING

2. When we cut ourselves the blood __________ at the wound to stop the loss of further blood. This is a natural defence mechanism of the body.

CLOTS

3. When the blood clots the clotting factors present in the plasma form a mesh and the blood cells become trapped in it.

(No answer required for this frame)

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4. In order to work, an anticoagulant must, therefore, interfere with one or more of the clotting factors present in the p__________

PLASMA

5. Often in the laboratory examination of blood we need to prevent the clotting of blood, so that we can examine the cells in it, which would otherwise be engulfed in the clot. To do this we add an __________ to the blood when it is taken out of the body.

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[1] We are grateful to Mr Brian Doughty, Senior Lecturer in Medical Laboratory Subjects, Kettering Technical College, England, for preparing this programme.

Annex 5

ANTICOAGULANT

6. If we do not add an anticoagulant to the blood when it is taken out of the body, the blood ______________ and the c________________ become trapped in the clot. This is why we add an anticoagulant to the blood.

CLOTS
CELLS

7. A good anticoagulant should preserve and have the minimum effect on the blood constituents.

(No answer required for this frame.)

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8. The essentials of a good anticoagulant are therefore:

(a) To p________________ and

(b) To have the m____________ effect on the blood constituents.

PRESERVE
MINIMUM

9. The first anticoagulant we shall deal with is Wintrobe's mixture. (Heller and Paul's mixture.)

(No answer required for this frame.)

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10. W________________ mixture consists of:

Ammonium oxalate	1.2g
Potassium oxalate	0.8g
Distilled water	100ml.

WINTROBE'S

11. Potassium o________________ alone causes the shrinkage of the red cells, the addition of a__________ ________________ neutralizes this effect.

OXALATE
AMMONIUM OXALATE

12. If we did not add the ammonium oxalate to the p______________ oxalate the red cells would s________________

Annex 5

POTASSIUM
SHRINK

13. 0.2ml of the mixture which contains:

________________ ________________ 1.2g

________________ ________________ 0.8g

is added to a container. It is then dried at a temperature not exceeding 80°C.

AMMONIUM OXALATE
POTASSIUM OXALATE

14. The amount of anticoagulant in each container is __________ ml. This is sufficient to stop the clotting of 2ml of blood when mixed thoroughly with it.

0.2ml

A. How much ammonium oxalate and how much potassium oxalate in mg are required to stop the clotting of 5 ml of blood?

(If you cannot answer this refer back to frames 10, 13 and 14.)

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6 mg
4 mg (Good)

15. One of the clotting factors present in the __________ is calcium ions.

PLASMA

16. The __________ oxalate and __________ oxalate combine with the calcium ions to form insoluble calcium oxalate.

AMMONIUM
POTASSIUM

17. The insoluble __________ oxalate cannot be used in blood coagulation.

CALCIUM

18. __________ mixture does have some disadvantages. Firstly, it distorts the white cells in the blood. When we wish to examine the white cell morphology we must, therefore, remove a sample and make a blood film as soon as possible.

WINTROBE'S

19. Besides distorting the __________ cells a second effect is to cause the platelets to clump. Blood taken into __________ mixture, therefore, cannot be used for counting platelets.

WHITE
WINTROBE'S

20. The last disadvantage is that because Wintrobe's mixture contains ammonium ________________ it cannot be used for the biochemical estimation of urea, as the ammonia would be estimated with the urea, which is converted to ammonium carbonate in the test.

OXALATE

21. Wintrobe's mixture contains ________________, ________________ and ________________ ________________

AMMONIUM OXALATE
POTASSIUM OXALATE

22. Wintrobe's mixture has three disadvantages:

(a) It distorts the ________________ cells

(b) It clumps the p________________

(c) It cannot be used for estimation of u________________

WHITE
PLATELETS
UREA

23. The next anticoagulant we shall deal with is sequestrene. The chemical name for this is ethylenediaminetetraacetic acid (edetic acid). This is now more generally used than Wintrobe's mixture as a routine anticoagulant in haematology.
(No answer is required for this frame.)

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24. S________________ is ethylenediaminetetraacetic acid. The di-potassium salt is usually used because it is more soluble than the di-sodium.

SEQUESTRENE

25. Di________________ ethylenediaminetetra________________ is more soluble than the di-sodium salt. Sequestrene can be used either in a dry or liquid form.

Annex 5

POTASSIUM
ACETIC ACID

26. The dry form is used as an anticoagulant for blood. 0.1 ml of a 5% aqueous solution of e____________________diaminetetraacetic acid is pipetted into a bottle and allowed to dry at room temperature.

ETHYLENE

27. The amount of ethylene __________________ acetic acid in each bottle is _______ ml. This is sufficient to stop the clotting of 2 ml of blood when mixed thoroughly with it.

DIAMINETETRA
0.1 ml

B. How much sequestrene in mg is required to stop the clotting of 4 ml of blood? (If you cannot answer this go back to frames 26 and 27.)

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10 mg (Good)

28. The liquid form of ____________________ is used as an anticoagulant for bone marrow.

Di-potassium ____________________________________ 3%
NaCl 0.7g.
Distilled water 100ml.

1 volume of this is sufficient to stop the clotting of 19 volumes of marrow.

SEQUESTRENE
ETHYLENEDIAMINETETRAACETIC ACID (EDETIC ACID)

29. Another clotting factor present in the ____________________ is anti-haemophilic globulin/factor (A.H.F.).

PLASMA

30. Sequestrene inhibits clotting by inactivating the A.H.F. (____________________ _______________ _________________) and binding the calcium.

ANTI-HAEMOPHILIC GLOBULIN OR FACTOR

31. Anti-haemophilic factor is used in the early stages of blood clotting. It is for this reason that the platelets remain stable, because they are affected by changes early in the clotting mechanism.

(No answer is required for this frame.)

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32. Sequestrene, although it does distort the white cells after a few hours, has none of the disadvantages of Wintrobe's mixture, which are:

1. ______________________
2. ______________________
3. ______________________

Sequestrinated blood cannot be used for prothrombin estimations.

DISTORTION OF WHITE CELLS
CLUMPING OF PLATELETS
CANNOT BE USED FOR THE ESTIMATION OF UREA

33. Sequestrene cannot be used for the estimation of pro______________

THROMBIN

34. The third haematological anticoagulant we shall deal with is heparin. This is a natural anticoagulant found normally in the plasma, being secreted by the white cell called the basophil.

(No answer required for this frame.)

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35. H______________ is a naturally occurring anticoagulant secreted by the b______________ It is made commercially from pigs' lungs which are rich in these cells.

HEPARIN
BASOPHIL

36. An aqueous solution of heparin (commercially prepared from pigs' ______________) containing 400 mg /100 ml. 0.25 ml of this is pipetted into a bottle and allowed to dry at 37°C.

LUNGS

37. The amount of heparin in each bottle is ________ ml. This is sufficient to stop the clotting of 5-10 ml of blood for at least 24 hours, if well mixed.

0.25 ml

C. How much heparin in mg is sufficient to stop the clotting of 5-10 ml of blood?

(If you cannot answer this refer back to frames 36 and 37.)

Annex 5

1 mg (Good)

38. A third clotting factor found in the ______________ is thrombin, which is produced when its precursor prothrombin is activated in the clotting mechanism.

PLASMA

39. Heparin works by neutralizing thrombin in the presence of a co-factor in the albumin fraction.

(No answer is required for this frame.)

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40. HEPARIN WORKS BY NEUTRALIZING:

(a) Calcium ions.
(b) Prothrombin
(c) Anti-haemophilic factor
(d) Thrombin

Select which.

If you selected (d), go on to the next frame. If you selected any other refer to frames 38 and 39.

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41. Thrombin takes part in the last stages of clotting. The p______________ which are affected by the early changes in the clotting mechanism will not/will be preserved by heparin.

PLATELETS
WILL NOT

42. Besides affecting the ______________, heparin gives a blue colouration to the background of blood films.

PLATELETS

43. Heparin is useful when it is important to minimize the chance of haemolysis. It is for this reason, and also that it is a n______________ occurring anticoagulant that heparin is used for osmotic fragility tests. Artificial anticoagulants can affect the results of this test.

NATURALLY

44. Heparin is used for o________________ fragility tests. (This is a test where red cells are suspended in salt solutions of various concentration to see at which strength they lyse.)

OSMOTIC

45. The last anticoagulant we shall deal with is trisodium citrate. (No answer required for this frame.)

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46. Tri________________ citrate is used as 3.8 g /100 ml aqueous solution.

SODIUM

47. ________________ % trisodium c________________ is used as a liquid anticoagulant. 1 part to 9 parts of blood and thoroughly mixed.

3.8
CITRATE

48. 1 part of tri________________ ________________ is sufficient to stop the clotting of ________________ parts of blood.

SODIUM CITRATE
9

49. ____________ % t____________ ____________ is used mainly as an anticoagulant in investigating disorders in the blood clotting mechanism in blood transfusions, and also for performing the erythrocyte sedimentation rate when 4 parts of blood are added to 1 part of sodium citrate.

3.8
TRISODIUM CITRATE

50. ____________ % ________________ sodium citrate is used mainly for investigating blood ________________ disorders, ________________ transfusion and for the ____________ ________________ ________________ (ESR).

Annex 5

3.8

TRI

~~CLOTTING~~

BLOOD

ERYTHROCYTE SEDIMENTATION RATE

51. Sodium citrate works as an anticoagulant by de-ionizing the calcium ______________ and inhibiting the conversion of prothrombin to thrombin.

IONS

52. De-______________ calcium cannot be used in blood clotting.

IONIZED

53. Being a liquid anticoagulant it will dilute the cells in the blood by about ______________ part(s) in 10. This means it is not possible to count accurately the numbers of cells present.

1

54. Sodium citrate is therefore not used for ______________ counting in haematology.

CELL

55. Regardless of what anticoagulant we use certain changes do take place when blood is allowed to stand in vitro. These can be minimized by keeping the blood in a refrigerator at 4°C. It is important however to note that blood should be allowed to return to room temperature before any investigations are carried out.

TEST

A. What is an anticoagulant?

B. What are the essentials of a good anticoagulant?

C. 1. What is in Wintrobe's mixture?

2. Why do we use two salts?

3. What is its mode of action?

4. What are its disadvantages?

D. 1. What is sequestrene?

2. How does it work?

3. What are its disadvantages?

4. What are its advantages?

E. 1. Where is heparin normally found?

2. Where is it produced?

3. How does it work?

4. What are its disadvantages?

5. What are its uses?

F. 1. What is sodium citrate used for in haematology?

2. How does it work?

3. What are its disadvantages?

ANNEX 6. SAFETY IN THE MEDICAL LABORATORY

In view of the growing awareness of the need for a safe laboratory environment, safe procedures and safe reagents, it is important to introduce the concept of safety to the student in the early days of his course. It will be the responsibility of the laboratory tutor to initiate a safety consciousness. This will be achieved both by regularly introducing the concept of safety at appropriate points in the course and by conducting a series of lectures and discussions specifically focused on the subject. Furthermore, strict safety rules should be observed in all training procedures, with laboratory rules being clearly displayed in all practical areas.

Courses in laboratory safety should include the following topics:

General safety

(1) The functions of a safety officer, general precautions for all staff, including fire drill, use of protective clothing, rules concerning eating, drinking and smoking in the laboratory.

(2) First aid instruction, safety in relation to electrical apparatus. Handling of compressed and liquified laboratory gases, solid carbon dioxide, spillage of hazardous chemicals.

(3) Handling of general laboratory equipment including vacuum equipment, autoclaves, centrifuges (including micro-haematocrit centrifuge).

(4) The hazards of aerosols and droplets, specimen containers. The risks involved in blood collection, dispatch and receipt of specimens, "high risk" specimens.

(5) Disinfectants, different types available and optimum concentration for use.

(6) Protection of laboratory staff, including immunization, medical checks, etc.

Safety precautions in the clinical chemistry laboratory

(1) Hazards of methods of collection, containers, pipettes, needles, automated equipment.

(2) The dangers inherent in certain equipment such as high voltage electrophoresis, flame photometers, gas cylinders, bunsen burners, fume cupboards, condensers and glassware.

(3) Dangerous chemicals and materials including picric acid, exothermic reagents, cyanide solutions, oxidizing reagents, automated equipment, effluent, mercury, acetone and chromic acid, perchloric acid. Storage of poisons, volatile fluids and substances used in "*in vivo*" tests. The handling of carcinogenic aromatic amines.

Safety in haematology and blood transfusion laboratories

Collection and handling of specimens, both venous and capillary. Treatment of pipettes. The risk of viral hepatitis.

Safety in the microbiology laboratory

(1) The handling of pathogens and specimens containing pathogenic material, cultures, slides. Hazards of centrifuges and containers.

(2) The cleaning of infected apparatus.

(3) General precautions in the microbiological laboratory including precautions against tuberculosis, animal work, post-mortem examinations.

Annex 6

Safety in the histology laboratory

(1) Hazards of the cryostat, fire risk involved in the handling of paraffin wax, alcoholic stains, ether, benzene, xylol and in particular celloidin.

(2) Chemical hazards from fixatives, cyanide solutions, oxalic acid solution, glacial acetic acids, etc. Explosive hazards of ammoniacal silver solutions, and picric acid.

(3) Precautions to be observed in the specimen and "cutting-up" room.

Specialist situations

Safety practice in the isotope laboratories, animal houses.

Safety concepts in laboratory design

Flooring; walls, doors. Washing facilities.