CURRICULUM

AND

TEACHER'S SYLLABUS

FOR SCHOOLS OF X-RAY TECHNOLOGY

A TEACHING GUIDE

PUBLISHED BY

THE AMERICAN SOCIETY OF X-RAY TECHNICIANS

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SECOND EDITION

TABLE OF CONTENTS

FOREWORD

The Preface to the first edition of the "Basic Curriculum and Teacher's Syllabus in X-Ray Technology" states: "The American Society of X-Ray Technicians has had from its inception the objective, as outlined in its Articles of Incorporation and By-Laws, 'To promote the science and art of radiography, and to study and discuss all the subjects pertaining thereto.' "

The first edition, published in 1954, enjoyed an unprecedented popularity as a guide to directors of training schools in organizing their instructional programs. Its format followed the "Basic Minimum Curriculum" for a one year course in x-ray technology as approved by the Board of Chancellors of the American College of Radiology, the Council on Medical Education and Hospitals of the American Medical Association and the Board of Directors of The American Society of X-Ray Technicians.

With increasing emphasis upon the desirability of a two year program of study and training culminating in action taken in 1959 by the Board of Chancellors of the American College of Radiology endorsing the two year school as the goal to be sought for an approved program in the future, the need for a revised Teacher's Syllabus became apparent.

The Second Edition is the product of many minds. It is estimated that more than fifty educators—technicians and radiologists—have collaborated in its development. Sponsored jointly by The American Society of X-Ray Technicians and the Commission on Technician Affairs of the American College of Radiology, much of the basic spadework was done by the Education Committee of The American Society of X-Ray Technicians with the assistance of the Greater St. Louis Educational Council. Of great help to the group of editors were the "Instructor's Syllabus in Radiographic Technology" published in 1959 by the Canadian Society of Radiological Technicians in cooperation with the Canadian Association of Radiologists and the "Standard Curriculum and Course Outline for Two year Schools of X-Ray Technology," published in 1959 by the Committee on X-Ray Technology of the Catholic Hospital Association of the United States and Canada. Liberal use has been made of material from both of these sources and gratitude is expressed to these organizations for this privilege.

The Second Edition of the Teacher's Syllabus is developed in two sections: Part One includes outlines of courses which are believed to be essential to the conduct of an approved training school. Part Two includes outlines of elective courses which may or may not be given at the discretion of the director. It is hoped by the editors that the material in both sections will prove helpful to school directors and instructors in organizing their educational programs so that their students may develop into mature, experienced and reliable technicians. It should be emphasized, however, that this Syllabus should be considered as a guide and not as a system of required courses to be rigidly followed. Undoubtedly some directors will wish to organize and conduct their programs along wholly different lines than those proposed. On the other hand, experience with the first edition of the Teacher's Syllabus has indicated that many instructors wish more detailed suggestions regarding course content than were present in the earlier edition. It is hoped that something of value is herein provided for both groups. At the least it should provide a useful guide or framework upon which the experienced teacher may build each course to meet the needs of his students.

The editors realize that the most important part of a training program is the applied or practical application. It is believed, however, that unless a student is well-grounded in the basic principles involved in x-ray technology, he may not only fail to understand the fundamentals of what he is learning to do with his hands and his mind, but he may also be handicapped in his development as a professional assistant to his radiologist and in his ministrations to the patients whom both serve.

In general, the course is designed to be presented in approximately 400 teaching hours, including lectures, demonstrations, discussions or seminars, film critiques and review. It is expected that some instructors will wish to concentrate didactic sessions during the early weeks of training. If so, this should be followed by less concentrated but regularly conducted teaching exercises—at least two a week—during the remainder of the two year training period. If not, most teachers have found that one instructional session each day of one or more hour's duration, five days a week, forty or more weeks a year, is the most effective approach to adequate presentation of matrial. Weekly film critiques may be counted as one of the five weekly teaching exercises. It is especially urged that classes be held regularly and on schedule

and during the normal day hours of operation of the department.

The final six months of training can be profitably used to perfect the skill of students in performance of some of the more exacting techniques and in increasing their understanding of what they are doing in a practical way. During these final weeks, review of much of the didactic work previously presented is helpful in clearing up points not previously made clear and in emphasizing to the senior students material which they were not sufficiently mature to appreciate at the time of the original coverage.

A. BRADLEY SOULE, M.D.,
Chairman,
Commission on Technician Affairs,
The American College of Radiology.

RALPH J. BANNISTER, R.T. (ARXT),
Board of Directors,
The American Society of X-Ray Technicians.

Chapter I

GENERAL CONSIDERATIONS

In establishing a curriculum for the guidance of teachers and students in radiological technique it is believed that a certain number of hours must be allocated for guidance in the teaching of each subject. The order in which each subject is to be taught must be left to the head of each training institution. Frequently several courses may be taught simultaneously; i.e., Anatomy and Physiology at the same time as Positioning; Medical Terminology one hour per week over a period of one semester, etc.

For a number of years it has been a requirement of the Commission on Technician Affairs, backed by actions of the Council on Medical Education and Hospitals of the American Medical Association, that an approved school must provide a minimum of five hours per week of class-room instruction, exclusive of holidays and vacations.

Assuming that a short period of concentrated didactic instruction is given to newly enrolled students, it is suggested that with classes held five days per week (four didactic sessions and one film critique) forty weeks of the year, ample time should be provided for all basic courses, for one or more elective courses and for review. With these principles in mind, the following is recommended as a Basic Curriculum together with a suggested sequence of presentation:

First Year — First Semester SUBJECT:	Theory Clock Hours
Orientation and Elementary Radiation Protection	5 hours
Professional Ethics	4 hours
Office Procedures (see Chapter V)	
Anatomy and Physiology	30 hours
Physics	20 hours
Darkroom Chemistry and Technique	10 hours
Principles of Radiographic Exposure I	10 hours
Radiographic Positioning—Section A	15 hours
Medical Terminology (see Chapter XI)	
Film Critique	20 hours
Total	114 hours

First Year — Second Semester	
Physics (cont'd)	20 hours
Radiographic Positioning (Section A cont'd)	15 hours
Principles of Radiographic Exposure I (cont'd)	10 hours
Common Radiographic Procedures Using Contrast Media	8 hours
Nursing Procedures Pertinent to Radiology	10 hours
Pediatric Radiography	8 hours
Film Critique	20 hours
Total	91 hours

Second Year — First Semester SUBJECT:	Theory Clock Hours
Radiographic Positioning (Section B)	30 hours
Principles of Radiographic Exposure II	10 hours
Protection to Patients and Personnel	10 hours
Special Radiographic Procedures	20 hours
Topographic Anatomy	12 hours
Film Critique	20 hours
Elective	4 hours
Total	106 hours

Second Year — Second Semester SUBJECT:	Theory Clock Hours
Radiation Therapy	10 hours
Intraoral Radiography	8 hours
A Survey of Medical and Surgical Diseases	15 hours
Departmental Administration	10 hours
Equipment Maintenance	6 hours
Film Critique	20 hours
General Review	20 hours
Electives	20 hours
Total	109 hours

Electives:

- Psychology
- Medical Use of Radioisotopes
- Photography
- Principles of Teaching
- Research in Relation to the X-ray Technician
- Technical Writing
- Radiological Mathematics for Technicians
- Civil Defense
- Journal Club (no outline)
- Typing (no outline)

Chapter II

SUGGESTIONS REGARDING THE ORGANIZATION OF A TRAINING SCHOOL FOR X-RAY TECHNICIANS

It is currently required that for an x-ray technician to be qualified for registration by the American Registry of X-Ray Technicians, the technician must have completed successfully a two year program of study and practical application in a hospital radiology department directed by a Board-qualified radiologist or in an office of a qualified radiologist. The Commission on Technician Affairs of The American College of Radiology and The American Society of X-Ray Technicians believe that the best possible type of training can usually be provided in a two year school of x-ray technology,—preferably one that is approved by the Council on Medical Education and Hospitals of the American Medical Association. In such an environment, the student will have the opportunity of working on a diversified group of cases including seriously ill or injured patients,—many of whom require great skill in handling and which call upon the ingenuity of the technician to obtain the most informative radiographs possible with the least handling of the patient.

An entirely acceptable and creditable training school can be organized in relatively small as well as large general hospitals, provided there is a sufficient quantity and variety of material for adequate experience. Some of the finest programs in the country are in medium-sized institutions.

The key to success appears to lie in the combination of an interested radiologist, a hospital administration which is sympathetic to the successful operation of the school and a dedicated instructional staff including a chief technician who is teaching-oriented and who is able to devote a large proportion of his time to the program of the school. Adequate equipment and facilities are essential but need not be elaborate; likewise, a training program is not, of necessity, expensive except as regards the time and interest of the teaching staff.

The suggestions which follow are based on what is felt to be an ideal situation; most of them can be attained without too great difficulty in almost any general hospital. However, a good teacher will find that he can achieve the desired goal of educating well-rounded and capable technicians under less than ideal conditions.

Many radiologists and hospital administrators have been loath to organize a school of x-ray technology because of the expense. Cost accounting studies made of several medium-sized schools have indicated that, in most instances, it was no more expensive to operate a school than to staff the department with graduate technicians alone. The Commission is strongly opposed to the development of a school as a source of cheap labor and where such exists has made every effort possible to stop the practice. On the other hand, it is possible to organize the technical staff so that, even with the very best of instruction being provided to students, the total operating budget is no greater than in a non-teaching department.

ESSENTIALS OF AN APPROVED SCHOOL. In the case of a new school, it is possible to obtain provisional approval by the American Medical Association Council and by the Commission on Technician Affairs of The American College of Radiology, provided certain criteria are met. The application should be initiated by the radiologist-director of the school through a letter addressed to the Council on Medical Education and Hospitals, American Medical Association, 535 North Dearborn Street, Chicago 10, Illinois. The school will then be visited and surveyed for the College and Council by a Councilor of the College. Action will follow by the Commission on Technician Affairs and by the Council. If the school is granted the status of provisional approval, it will be listed as approved by the American Medical Association Council; it will automatically be re-surveyed following the graduation of its first class.

A school already on the "Approved" list is surveyed automatically at periodic intervals,—usually every five years. The school is also surveyed if there has been a change in the radiologist directing the school or if evidence is presented to either Council or Commission that the school may not be functioning in an approved manner.

Acceptable schools may be conducted by approved medical schools or radiology departments affiliated with a general hospital. Under special circumstances, schools may be developed in certain specialty hospitals such as a pediatric institution, or in small general hospitals where no experience can

be obtained in the performance of some of the more highly technical procedures, or in radiation therapy. Under such circumstances, students should affiliate for a month or more with an institution where training in these specialized procedures can be provided.

As regards volume of patient material, it is doubtful that a hospital radiology department which performs less than 6,000 examinations per year provides enough material for proper instruction. The Commission on Technician Affairs recommends that at least 1,500 examinations per student should be performed annually, exclusive of photofluorographs. Thus a radiology department which performs about 18,000 examinations annually could be approved for a total of not more than 12 students.

While it is recognized that as few as one or two students may be enrolled at any one time, the Commission on Technician Affairs has found that schools with larger enrollment,—five or more students in a class,—usually provide more effective instruction with more efficient use of teaching personnel.

The hospital administration should express its interest in the school by assuring proper financial support for the effective operation of the school and by providing a classroom with its required teaching aids, and a library and study space. It should also assist in the student health program and in the sharing of its staff for certain phases of specialized instruction such as nursing procedures, administrative methods, etc.

ORGANIZATION AND FACULTY. The school must be directed by a radiologist,—frequently but not invariably the chief of the hospital radiology department. The assistant director is usually but not invariably the chief technician. Without the close co-operation of both, working as a team whose goal is to perform the highest possible type of technical work and to give the best possible training to their students, an effective program cannot be developed or carried out.

The radiologist-director will assume responsibility for organization and administration of the school and for establishment of policy. He will select the instructional staff and will assign subject material to each teacher. He will usually conduct some of the classes himself,—particularly those concerned with medical and radiologic problems and relationships. Since of necessity the duties and responsibilities of the radiologist in the field of clinical radiology engage the major portion of his time, he will frequently call upon his associates and residents to conduct some of the teaching in which medical and radiologic training are most effectively utilized; likewise, he will rely upon the chief technician to supervise the rest of the active teaching, both didactic and practical.

The role of the chief x-ray technician and his duties and responsibilities will vary widely. In the small school with less than six students, he will usually have time to do a certain amount of the routine technical work of the department in addition to teaching and administrative responsibilities. In most schools with six or more students the chief technician should be in a position to devote almost his entire time to teaching and administration. Under him should be a corps of well-trained technicians who are capable of assisting in classroom instruction as well as in the practical teaching of students and who can take over the important task of supervising and performing the general technical work of the radiology department.

It is required that there shall be at least one graduate staff technician for each three students enrolled in the school.

In schools affiliated with medical colleges or in hospitals with training schools for nurses, it will frequently be possible to secure the services of instructors in anatomy, physiology, nursing procedures, physics, etc. Residents in radiology and other services often make excellent instructors in such courses as anatomy-physiology, medical and surgical diseases and their relation to x-ray technology, etc.

GENERAL FACILITIES. The radiology department should be housed in suitable quarters and provided with modern equipment adequate to allow performance of all types of x-ray examinations and treatments which are usually performed in a general hospital. Installations should conform to the requirements of the Bureau of Standards for protection of patients and working personnel as outlined in Handbook 60. Suitable protective devices, such as lead-lined booths, collimators or cones, filters, lead-rubber screening, aprons and gloves should meet all present requirements and should be properly utilized.

CLASSROOM, LIBRARY AND STUDY FACILITIES. These should be of such a nature that adequate instruction may be provided and that an atmosphere conducive to study is present.

It is essential that the library include most of the standard texts on x-ray technology and radiographic anatomy as well as a number of specialized reference works. The textbooks listed in the bibliography of this Teacher's Syllabus provide the basis for an excellent departmental library.

Students will undoubtedly be required to own certain textbooks of their own. Even though this may entail an expenditure of fifty dollars or more, this should be looked upon as an essential investment in learning. Each student should subscribe to THE X-RAY TECHNICIAN in order to keep abreast of developments in the technical field.

Probably the most widely used texts are the following:

A HANDBOOK OF ANATOMY AND PHYSIOLOGY—M. Mallett, M.D. (ASXT Executive Office)

TEXTBOOK OF ANATOMY AND PHYSIOLOGY—Kimber, Gray, Stackpole, Leavell. (MacMillan)

AN ATLAS OF NORMAL RADIOGRAPHIC ANATOMY—I. Meschan, M.D. (Saunders)

THE FUNDAMENTALS OF X-RAY AND RADIUM PHYSICS—Joseph Selman, M.D. (Charles C. Thomas)

MANUAL OF ROENTGENOLOGICAL TECHNIQUE—L. R. Sante, M.D. (Edwards Brothers)

FORMULATING X-RAY TECHNICS—J. B. Cahoon, R.T. (Duke University Press)

PRINCIPLES OF RADIOGRAPHIC EXPOSURE AND PROCESSING—Arthur Fuchs (Charles C. Thomas)

MILITARY ROENTGENOLOGY, T. M. 8-280—War Department (Supt. of Documents, Washington, D. C.)

POCKET MEDICAL DICTIONARY—(Any of several)

MEDICAL RADIOGRAPHIC TECHNIQUE—Glenn W. Files, et al. (Charles C. Thomas)

PATIENT CARE AND SPECIAL PROCEDURES IN X-RAY TECHNOLOGY—J. C. Watson, R.T. and Carol Hocking Vennes, R.N., B.S. (C. V. Mosby Company)

X-RAY PROTECTION, HANDBOOK 60—U. S. Department of Commerce, National Bureau of Standards (Supt. of Documents, Washington, D. C.)

Supplementary textbooks and books on radiographic positioning are listed in the booklet, "Training Aids for Schools of X-Ray Technology" which may be obtained from the Executive Secretary, The American Society of X-Ray Technicians, 16 Fourteenth Street, Fond du Lac, Wisconsin.

In the classroom, many other teaching aids are useful. An articulated skeleton together with a collection of individual bones, anatomical models and charts, line drawings, disassembled electrical and x-ray equipment and old x-ray and valve tubes, are useful adjuncts to training. Slides, motion pictures and tape recordings are available from many sources and are listed in the booklet "Training Aids."

A teaching file of radiographs is also invaluable. An excellent way to start a file of this sort is to keep a notebook in the processing room in which may be recorded the names and numbers of radiographs with potential teaching features. Hundreds of excellent teaching specimens illustrating positioning, technical mistakes, processing errors, artifacts, etc., can be obtained in this way. These should be placed in envelopes and coded into the teaching file. To these may be added radiographs especially made for teaching purposes, i.e., illustrating relative speeds of various films, the intensifying factors of different speed screens, common reasons for Bucky lines, clean-up effect of grids, large cones versus small cones, effect of collimators, differences in photographic effect produced by changing any of the exposure factors, plus a host of other worthwhile experiments.

Models of x-ray circuits can be built by enterprising teachers or may be purchased from vendors of scientific equipment. Sante recommends a model which can be dismantled and then re-wired by each student.

INSTRUCTIONAL PROGRAM. The organization and implementation of the curriculum is the responsibility of the radiologist and head technician. They must decide how the various courses relating to x-ray technology are to be taught. Common sense dictates that the basic material should be presented first and that there should be an orderly progression of learning. Basic physics should precede the study of electricity and radiation physics; however, anatomy and physiology may be taught before or in conjunction with radiographic positioning, provided that they are correlated.

The instructors will have to decide for themselves how best each subject may be presented in order to lay the proper groundwork for knowledge of the subjects which an x-ray technician should know. Effective instruction does not just happen but is the result of careful preparation. It is necessary that each teacher prepare adequately for every assignment and present the lesson in an accurate, complete and concise manner. Repetition is frequently valuable, the important parts being presented in several different ways until the student fully understands.

As mentioned above, the use of visual aids is essential to a teaching program of this sort and is more effective than words alone.

Classroom instruction should average a minimum of five hours per week as required by the accrediting organizations. Film critiques by the radiologists, residents or head technicians may be included. This undergraduate training should be so conducted as to provide a solid foundation for the technician's future development. It should aim at presenting all of the basic subjects pertaining to x-ray technology and as many electives as possible. The purpose of the didactic courses is to give the student knowledge and appreciation of what he is doing when he is making an x-ray examination or processing a radiograph. Most students will not require anything approaching the knowledge of such subjects as physics, chemistry and anatomy as are required of a medical student but an experienced and wise teacher will usually be able to organize the courses so that they will have meaning to the young student who is frequently just out of secondary school and usually has a limited background in scientific knowledge.

One of the most common deficiencies noted by inspectors of schools of x-ray technology is that, largely due to the pressure of work in the department, classes are omitted or not held on schedule. The accrediting committees take the stand that there should be a sufficient number of staff technicians and senior students in the department so that classes may be held regularly, regardless of the work load of the department.

Examinations are important ways of evaluating progress of training. Only through testing can the student and instructor know what progress each is making. It is as important for the teacher to know how well he is teaching as for the student to know how much he has learned.

Examination grades should be made a part of the student's record. It is well for the teacher to go over the written examination papers with the students after grading so that defects can be corrected.

Technical training cannot achieve its aim if the student is relegated to a passive role and does not take an active part in the function of the radiology department. Students are not in the department merely to perform menial tasks but should be instructed to assume a certain amount of responsibility in carrying out radiographic examinations. The practical training should be carefully supervised and must of necessity be individualized to meet the needs of each student. Some students are capable of accepting responsibility before others which means that the slow learners must often be given more time and help than the quicker ones.

AFFILIATED SCHOOLS. There are a number of x-ray training schools in the country where affiliation is present with a university, college or other school. These vary greatly but two principal arrangements are commonly in effect.

One is a plan under which a student enrolls in a junior college for a period of one to three years, this being followed by one and a half or two years of concentrated training in a hospital radiology department. The training program should be evaluated in advance by the American Registry of X-Ray Technicians, in order to be certain that graduates will be eligible to take Registry Examinations.

The other is a system whereby a group of training schools send their students to a single educational institution for didactic training. The official opinion regarding this plan is that there is merit in certain of them in which a well-organized series of lectures, demonstrations, seminars and other presentations are conducted by capable and experienced teachers.

On the other hand, such an affiliation should not relieve the schools so affiliated from responsibility for the training of their students and active teaching programs should also be conducted within the hospital schools themselves, particularly as regards on-the-job features of training in technical activities, handling of seriously sick and injured patients, darkroom procedures, etc. If classes are held some distance away from the hospital school, they should be given on released time and not during evening sessions after a full day of work in the department. Directors of hospital schools should consider the work done as a projection of their own school program as concerns interpretation of grades received and general performance of students in the courses taken. Students who fail in courses taken in the affiliated school should be considered as having failed in the hospital training school and directors of the hospital schools should take appropriate action in any such cases.

RADIATION THERAPY AND ISOTOPES. In the field of radiation therapy and isotopes, it is presently required that at least one month of practical training and experience be provided including at least ten hours of lectures by a radiologist or other qualified instructor. Special attention should be given to safety features from both patients' and technicians' point of view. It should be emphasized that technicians are never to administer radiation therapy; however, they should be taught to assist the radiologist in "setting patients up" and in operating

equipment but not to perform any of the functions which only a physician is trained and permitted to do.

In 1958 the Commission on Technician Affairs surveyed about seventy-five radiologists whose practice consists largely of radiation therapy or use of isotopes to attempt to find out what type of training would be most suitable for technicians working in these fields. A wide disparity was evident,—some radiologists wishing intensive training in physics, mathematics and other subjects,—others stating that they needed little more than "machine watchers." For those working with isotopes, some felt that it was important for a technician to be trained in laboratory procedures as well as in radiation technology.

As a result, no firm recommendations have been offered for training in these fields other than those stated above. However, included among the elective subjects in this Syllabus are chapters on "mathematics for technicians" and for training in radioisotopes. These are offered as suggestions only for those radiologists who wish to provide something more than the basic material.

RADIATION PROTECTION. The chief technician, under the radiologist, is usually responsible for the enforcement of departmental radiation protective regulations. He should see that students are at all times protected from excessive radiation by suitable barriers and that they always wear either film badges or pocket dosimeters. These should be read weekly or every two weeks and the results posted in a conspicuous place. When a high reading is encountered, the student's work habits should be investigated and appropriate measures taken.

As will be noted in the chapter under "Orientation" new students are usually given a list of "Do's and Don'ts" since they have had virtually no background knowledge of radiation. The course in radiation protection (Chapter XVI) is usually best given after the students have learned enough about the physics of radiation and machine operation to make the material more meaningful. One teaching exercise which graphically presents the problem of stray radiation is to place a Geiger counter or scaling unit in various parts of the fluoroscopic and radiographic rooms so that students may be shown the zones in which such radiation is most prevalent during various types of examinations. When the students are given instruction regarding their duties during fluoroscopy, knowledge of danger zones in the room makes these instructions more intelligible.

Students should not be allowed to operate x-ray equipment on patients until they have proven to the satisfaction of their supervisors that they are fully competent to do so. In practice, junior students first observe and then assist supervisors and senior students; only after they have mastered the equipment and techniques under close supervision and have demonstrated not only their knowledge of technical factors but also the basic principles of radiation protection, should they be allowed to make x-ray examinations without direct supervision.

With the increasing complexity of radiologic procedures in recent years and with the warnings given regarding possible genetic hazards from what in the past was not considered heavy exposure, it behooves us to see that technicians are adequately trained before they are released from school supervision. Regardless of the validity of arguments for or against genetic hazards, we are compelled to assume that the risks are there until proven otherwise and technicians must be thoroughly trained in understanding and applying all protective measures as far as patients and themselves are concerned. After all, nearly all radiation from x-ray equipment (except that administered by radiologists during fluoroscopy) is administered by technicians. The unskilled technician can, with several "retakes" of the lateral lumbar spine and pelvis, give radiation in one examination far in excess of that now considered as safe. On the other hand, the well-trained technician, studying and working under close supervision, can apply knowledge of anatomy, physics, use of filters, cones, collimators, lead rubber screening, machine factors, etc., so that such examinations can be performed with a minimum of gonadal exposure.

Technicians should be taught to screen with special care young children who are so small that most or all of their body may be included inadvertently in the beam when making an examination of an isolated part such as the skull, chest or an extremity. A limit should be placed on the number of retakes a student is allowed to make before a staff technician takes over and completes the examination. Some departments require that technicians record on the requisition slips of children and young adults a statement that lead shielding has been applied. They also record the time used during fluoroscopy of any patient.

SELECTION AND ADMISSION OF STUDENTS. Selection of the right type of person for training as an x-ray technician is extremely important. It is suggested that preference be given to applicants be-

tween 18 to 30 years of age. It is presently required that candidates be graduates of high school or the equivalent. Courses in physics, chemistry, mathematics and typing are strongly recommended. Students with poor grades in these subjects in high school frequently do not prove to be apt students in x-ray technology. It is suggested that candidates be encouraged to take Aptitude Test B 326 which is used by State Employment Offices in testing for aptitude in the field of x-ray technology. Through arrangements made with any State Employment Office in the country, prospective candidates may be tested and reports sent to the Director of any approved school of x-ray technology. In practice, the scores obtained by candidates have been found quite helpful in measuring aptitudes in intelligence (general learning ability), verbal (ability to understand meaning of words and ideas associated with them, and to use them effectively) and spatial (ability to think visually of geometric forms and to recognize relationships resulting from the movement of objects in space).

Since the personal qualifications of prospective students are of great importance, it is suggested that as much information as possible be obtained from teachers and others who know them well, particularly with regard to intelligence, reliability, industry and ability to get along well with others. The relative rank of the student in his class is often of more significance than his actual grades. Time spent in the careful investigation of applicants will insure that those who are chosen for training possess qualities of intellect and personality that will assure success in this field.

Each applicant should have a personal interview, preferably with both the radiologist and chief technician. The interviewers should be alert to recognize those attributes of appearance, attitudes, enthusiasm and manner that are indicative of the character of the individual. In some schools it is required that each prospective student spend one or more full days in the department. These visits provide both the candidate and the faculty with a fair chance to evaluate each other. This procedure tends to prevent students from dropping out of school after a few weeks because they did not understand what they were getting into and what was expected of them in their training.

RECRUITMENT. In areas where there is a paucity of well-qualified applicants for training schools, several techniques have been effective. One is for directors of the schools to write letters to counselors of all high schools and junior colleges in the area outlining the training program and describing the type of candidates which are most desirable. Brochures of the school and American Society of X-Ray Technicians leaflets "Careers in X-Ray Technology" should be enclosed. Counselors should be urged to encourage promising students to investigate the field and plans should be formulated whereby such students are invited to visit schools and have interviews with the radiologists and head technician.

Another effective method of recruitment is to develop a "Career Day" at which time high school juniors and others are invited to hospitals which operate training programs for nurses, x-ray and laboratory technicians, etc. Following an assembly session at which a representative of each training group describes briefly the program, the students are shown through the hospital and given the opportunity of talking with faculty members and staff and with students in training.

Another recruitment technique is for representatives of training schools to speak before assembly groups or classes in schools in the area. At such a time, much can be done to allay fears of radiation and interest can frequently be sparked in a number of young people who otherwise might never have considered x-ray technology as a career.

The various State Employment Services throughout the country administer the General Aptitude Test Battery and counsel about a quarter of a million high school seniors in over 8,000 high schools each year. Many of these students would have the required abilities, according to Dr. Beatrice J. Dvorak, Chief of the Division of Testing of the U. S. Department of Labor, Bureau of Employment Security, and might be interested in pursuing training for the occupation of x-ray technician. It is suggested that directors of training schools contact the Testing Division of the State Employment Service in their area and ask their co-operation in counseling promising students toward x-ray technology.

STUDENT HEALTH AND COUNSELING. It is desirable that each student be given a physical examination before or upon admission to the school. Many schools require a certificate from a dentist that the student's teeth are in good condition. It is usually required that each student be immunized against smallpox, diphtheria, tetanus, poliomyelitis and typhoid fever, and that sensitivity test for tuberculosis be performed. These should be supplemented by blood count, urinalysis and routine radiographic examination of the chest. Some schools require periodic health examinations one or more times a year—

these including blood counts and chest radiographs. All reports should be kept in the student's file in the school.

It is desirable that arrangements be made whereby students who are ill may be assured of medical and hospital care. The latter may frequently be arranged by group hospitalization insurance. Students who are ill should be required to report to a physician for examination and required treatment. A communicable illness must be reported promptly to the director of the school who will take appropriate action.

STUDENT RECORDS. Each student's record should be kept in a separate file folder. This should contain the application form, transcripts of the student's secondary and collegiate education, character references and other pertinent credentials. Records should be kept of attendance, examinations taken and grades received. A technical experience record should include the number and types of technical procedures performed and days spent in various assignments,—such as in the processing room, serving as assistant during fluoroscopic examinations, etc. The health record should include reports of admission physical and dental examinations and examinations performed while in training and records of any illnesses incurred. Time off from training because of illness or for other reason should be recorded; most schools require that this be made up at the close of the training period. Reports of dosimeter or film badge monitoring, periodic blood counts, etc., should be included. It is also helpful to include records of graduation and of subsequent employment, current address, etc.

TUITION, STIPENDS AND PERQUISITES. Many schools charge a tuition fee during the first year of training. This varies from twenty-five to three hundred dollars. There is no objection to and there are many arguments in favor of charging a reasonable tuition fee; this sets a value on the educational service rendered and places an obligation on the school to render this service. It helps to compensate the school for the higher salaries paid to head technicians and for the costs of supplying teaching aids, library and extra films consumed.

Recognizing that students also contribute to the operation of the department in service rendered by them, hospital schools often acknowledge this by allowances for board, room or laundry and, in the case of many two year schools, by payment of small stipends during the latter months of training. In the event of illness, the hospitals will frequently arrange for the medical and surgical care of students by the staff. Some hospitals will absorb part or all of the costs of hospital care of students over and above that allowed by group hospitalization insurance carried by the students.

Vacations of two weeks or more are usually granted annually. Additional time off may be granted during holiday seasons.

GENERAL. Given incentive to learn and guidance toward the grasp of principles underlying the science of x-ray technology, students have an opportunity to build towards a solid foundation for their future careers. In all of this the chief technician is of tremendous importance. Both by precept and by example he should keep the students ever mindful of their obligations to the patients, to the radiologist and to the hospital. Like a good captain of a good team he makes his influence felt throughout the training period. Students are quick to sense when the chief technician or any member of the school staff does not have his heart in his job and the effect on morale may be disastrous. His approach to teaching should be such that the students are eager to go along with him in the study of the subjects pertaining to x-ray technology and not to lag behind or to act as a buffer between him and the course being taught. As a teacher he must always remember that an individual does not necessarily learn by doing; he is more likely to learn by doing if what he is doing interests him. This focus of interest is the principal determinant in the quality of the student's performance. It is up to the teacher to find ways to develop this interest so that he may communicate his knowledge and skills more effectively.

The chief technician should urge the students to perform extra-curricular work, through critical reading of technical literature, through the preparation of articles on x-ray technique and through the use of the scientific method in approaching technical problems.

He must frequently act as counselor in attempting to solve student's personal, academic and technical problems. These discussions should be conducted with kindness, consideration and understanding,—the objective being to offer positive help and not to embarrass or humiliate the student. Most students do not want parent substitutes to tell them what to do, but often need desperately to talk over problems with someone whom they believe to be wiser than they. Here an effort should be made to assist students to get the most out of their training school ex-

perience and to assume responsibility for their actions and behavior so that they may mature in professional and personal growth.

Counseling may also extend to the staff technicians who should be reminded from time to time that it is natural and inevitable for students to make errors in judgment and technical mistakes.

The radiologist should be kept informed of any problems or situations involving students unless they are of a minor or trivial nature. Not only is he responsible to the hospital, patients and the referring physicians for the actions of his staff, but he holds a special type of responsibility to the parents of young people in training. Trained as a physician, he should be made aware of any personal problems of physical, emotional or mental health among his staff so that he may cope with them promptly and wisely.

(May, 1960)

Chapter III

ORIENTATION AND ELEMENTARY RADIATION PROTECTION

First Week

INTRODUCTION:

The beginning student will at best have only a vague idea about the field he enters, and its relation to the complete medical structure. Prior to starting his study in a detailed and progressive manner he should have an overall view of radiologic technology, and the part radiology plays in medicine, and should become acquainted with the general structure of applied medicine.

METHOD OF TEACHING: Lecture.

THEORY CLOCK HOURS: Four hours.

TIME: First year, first semester.

INSTRUCTORS: Radiologist, technician and hospital administrator.

I. Rules and Regulations of the Traning School:

A. Short welcoming address.
B. Repetition of information previously given through interviews and brochures, but further explained and emphasized.
C. Departmental rules and regulations.
D. Hospital rules and regulations.

II. A Brief History of Medicine (highlights):

III. The Paramedical Profession (A brief discussion of the scope of each and its relationship to the department of radiology):

A. Nursing.
B. Clinical laboratory technology.
C. Physical therapy.
D. Pharmacy.
E. Medical library science.
F. Dietetics and nutrition.
G. Radiologic technology.

IV. The Hospital and its Departments as an Organized Unit:

A. Governing board.
B. Medical director.
C. Hospital administrator.
D. The medical staff.
E. Resident staff.
F. Intern staff.
G. Medical students. (if medical school)
H. Admission service.
I. Outpatient service.

J. Department of radiology.
K. Clinical laboratories.
L. Pharmacy.
M. Physical medicine.
N. Social service.
O. Business office.
P. Housekeeping.

V. Organization of the Department of Radiology:

A. Radiologist.
B. Resident.
C. Chief radiologic technologist.
D. Radiologic technologist.
E. Instructors in technology.
F. Radiation physicist.
G. Radiation biologist.
H. Receptionist.
I. Bookkeeper.
J. Film record librarian.
K. Medical typist.

VI. History of Radiology:

A brief historical discussion of the discovery of x-rays and natural and artificial radioactive material may be presented. (The student at this time is not prepared to absorb and appreciate all of the important milestones in radiology.)

VII. Introduction to Radiologic Technology:

Aim: To give the student a general impression of what he will be expected to learn, expressed in simple terms.

A. Describe x-ray technology.
B. The production of the radiograph.
C. Value of x-radiation, diagnostic and therapeutic.
D. Basic radiation and electrical protection.
    1. As students at this time are not capable of understanding the mechanics of biological changes resulting from radiation it is suggested that a single lecture (1 hour) be given emphasizing the important safety features of this subject.
    2. Students should also be provided with a typewritten list of **do's and don'ts** regarding radiation and electrical protection to patients and personnel.

REFERENCES

1. **Dr. W. C. Roentgen;** Otto Glasser, Published by Charles C. Thomas, Springfield, Illinois. In this short but eloquent essay, Dr. Glasser tells the story of the "Discovery of X-Rays."

Chapter IV

PROFESSIONAL ETHICS

OBJECTIVES:

To acquaint the student with good ethical principles; to outline the responsibilities entailed by becoming a member of a paramedical profession; to explain the relationship of the x-ray technician to other technicians, the patients, the radiologist, attending physicians, and other members of the hospital staff.

METHOD OF TEACHING: Lecture and discussion.

THEORY CLOCK HOURS: Four hours.

TIME: First year, first semester.

INSTRUCTORS: Radiologist, chief technician.

I. Definition of Ethics.

II. Nature of Ethics.

III. Value of Ethics to the X-Ray Technician.

IV. Value of Ethics to the Patient.

V. Value of Ethics to the Medical Profession.

VI. Knowledge to be Kept in Confidence, regarding:

A. Patients.
B. Attending physician.
C. Institution.
D. X-ray technician.

VII. The Technician's Relationship to:

A. Patients.
B. Other technicians.
C. Radiologists.
D. Attending Physicians.
E. Other members of the hospital staff.

VIII. Professional Adjustment:

A. Cooperation with others.
B. The technologist's place in his professional organization.
C. The technologist's place in the community.

MISCELLANEOUS LEGAL AND ETHICAL PROBLEMS WITH SUGGESTED SOLUTIONS

I. Loan of Films.

II. Ordering of Examinations.

III. Ownership of Equipment:

A. By hospital or physician.

B. Never by x-ray technician.

IV. Visitors in X-Ray Rooms.

V. Using New Techniques.

VI. Care of Equipment.

PROFESSIONAL BEARING AND APPEARANCE

I. Personal Appearance, Posture, Cleanliness and Grooming.

II. Uniform:

A. Jewelry.
B. Cosmetics.

III. Courtesy.

REFERENCES

1. **Ethics;** Joseph B. McAllister, Ph.D., Published by W. B. Saunders Company, Philadelphia, Pa.

2. **Manual of Roentgenological Technique;** L. R. Sante, M.D., Published by Edwards Brothers, Inc., Ann Arbor, Mich.

Chapter V

OFFICE PROCEDURES

Many schools may wish to familiarize students with departmental records and office procedures early in their training. For the convenience of those who feel this to be a logical approach it is suggested that a discussion of departmental routines be supplemented by presenting at this time the material comprising Sections VI and VII of "Departmental Administration," Chapter XXII.

Chapter VI

ANATOMY AND PHYSIOLOGY

OBJECTIVES:

To give the student a basic knowledge of the various systems, structures, and organs of the body and their functions.

To enable the student to interpret accurately requests for x-ray examinations, to position the part or area to be radiographed, to recognize the structures and organs visualized, and to understand the normal functions of organs as a basis for certain x-ray examinations.

TEXT BOOK: This course may be taught directly from **"A Handbook of Anatomy and Physiology for X-Ray Technicians,"** by M. Mallett, M.D., Published by The American Society of X-Ray Technicians.

TEACHING AIDS: Skeleton, loose bones, anatomical charts, slides, motion pictures, blackboard.

THEORY CLOCK HOURS: Thirty hours.

TIME: First semester, first year.

INSTRUCTOR: Physician or other qualified instructor.

I. General nomenclature, anatomical names and terms.

II. Cells, tissues, organs, systems, divisions of the body, body cavities, congenital anomalies.

III. Density definition, tissue and organ density in radiography, contrast media, body thickness in radiography, and value of surface markings and bony prominences.

IV. Skin and appendages—skin, subcutaneous tissues, nails, hair, sebaceous glands, sweat glands, and function of the skin.

V. The Skeletal System: Bony prominences and depressions, functions of bone; classification, structure, development and application to radiography.

A. The shoulder girdle and upper extremity.
B. The pelvis and lower extremity.
C. The vertebral column.
D. The thorax.
E. The bones and joints of the skull.
F. Joints—articulations.

VI. The Muscular System. The classification, structure, function and distribution. Some of the muscles important to technicians.

VII. The Blood. Constituents of the blood:

A. Blood plasma or liquid, description and function.

B. Blood cells, description and function.

VIII. The Circulatory System:

A. Contents of the chest and thorax.

B. Structures of the circulatory system.

C. Important arterial and venous trunks.

D. Functions of the circulatory system.

E. Circulatory system of the fetus.

F. Application to radiography.

IX. The Respiratory System.

X. The Digestive System: Divisions of the abdomen and parts of the digestive system.

XI. The Urinary System.

XII. The Reproductive System: female and male.

XIII. The Endocrine Glands: Gross anatomy, physiology, some of the pathological conditions and their application to technology.

XIV. The Nervous System: The central and peripheral nervous systems, the structure and function of each, some anomalies and pathological conditions and their application to radiology.

XV. The Organs of Special Sense: The eyes and eyeballs, their application to radiography. The organs of hearing, smell and taste.

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2. **Human Anatomy and Physiology;** Millard and King, Published by W. B. Saunders Company, Philadelphia, Pa.
3. **Primary Anatomy;** Cates and Basmajian, Published by Williams and Wilkins Company, Baltimore, Md.
4. **An Introduction to Human Anatomy;** Marshall and Lazier, Published by W. B. Saunders Company, Philadelphia, Pa.
5. **An Atlas of Human Anatomy;** B. J. Anson, Published by W. B. Saunders Company, Philadelphia, Pa.
6. List and sources of slides and motion pictures on anatomy and physiology; **Training Aids for Schools of X-Ray Technology,** Published by The American Society of X-Ray Technicians; Executive Secretary's Office.

Chapter VII

PHYSICS

OBJECTIVES:

To teach the fundamentals of electrical and radiation physics and the basic principles underlying the operation of x-ray equipment and auxiliary devices.

NOTE: It is assumed that the student has completed high school algebra and geometry and is familiar with elementary mathematical principles which will assist him in understanding the fundamentals of radiologic physics.

METHOD OF TEACHING: Lecture, discussion, visual aids, demonstration by laboratory equipment.

THEORY CLOCK HOURS: Forty hours. Twenty hours each semester.

TIME: First year, first and second semester.

INSTRUCTOR: Chief technician and/or other qualified instructor.

I. Fundamental Units:

- A. Length.
- B. Mass.
- C. Time.
- D. Charge.

II. Derived Units:

- A. Area.
- B. Volume.
- C. Density.
- D. Specific gravity.
- E. Velocity.
- F. Temperature.

III. Mechanics:

- A. Force.
- B. Inertia.
- C. Energy.
  1. Forms.
  2. Law of conservation of energy.
- D. Work.
- E. Power.

IV. Matter:

A. Subdivisions of matter.
   1. Substances.
   2. Compounds.
   3. Elements.
   4. Atomic structure.
      a. Electrons, protons and neutrons, orbits.
      b. Atomic number.
      c. Mass number.
      d. Isotopes.
      e. Valence.
   5. The periodic table.

B. Ionization.
   1. By x-rays.
   2. By charged particles (i.e. electrons)
   3. By spontaneous breakdown of radioactive substances.
   4. Other electromagnetic radiation.
   5. Chemical.

V. Magnetism:

A. Classification of magnets.
   1. Natural magnets.
   2. Artificial magnets.
   3. Electromagnets.

B. Magnetic properties of various metals.

C. Repulsion and attraction.
   1. Poles.
   2. Law of magnetism.

D. Magnetic induction.

E. Magnetic fields.
   1. Representation by lines of magnetic force.

VI. Electricity:

A. Electrostatics.
   1. Methods of electrification.
   2. Types of electricity.
      a. Positive.
      b. Negative.
   3. Laws of electrostatics.
   4. Transfer of electricity by contact.
   5. The electroscope.
   6. The condenser.

B. Electrodynamics.
    1. Nature of electric current.
    2. Sources of electric current.
    3. Direct current.
        a. Properties.
        b. The simple cell.
        c. Purposes for which DC is employed.
    4. Alternating current.
        a. Properties.
        b. Wave form.
        c. Frequency.
        d. Advantages of AC.
    5. Measurement of electric current.
        a. Units: ampere, milliampere, microampere, etc.
        b. Ammeter.
            1) Principle.
            2) Method of connection into circuit.

C. Electromotive force.
    1. Nature of electromotive force.
    2. Measurement of electromotive force.
        a. Units: volt, kilovolt, (peak kilovoltage and effective voltage).
        b. Voltmeter.
            1) Principle.
            2) Method of connection into circuit.
        c. Spark gaps.

D. Electrical resistance.
    1. Nature of resistance.
        a. Properties of various metals.
    2. Ohm's law.
    3. Production of heat.
    4. Line drop.
    5. Resistive devices.
        a. Resistor.
        b. Rheostat.
    6. Uses of resistance.
        a. Control of current.
        b. Consumption of voltage.
    7. Insulators.

E. Electric power.
    1. Rate at which electricity does work.
    2. Units: watt, kilowatt, kilowatt-hour.
    3. Calculation of electric power.
    4. Electrical horsepower.

F. Electric circuits.
    1. Series circuit.
    2. Parallel circuit.
    3. Three wire system.
    4. Fuses and circuit protection.

VII. Electromagnetism:

A. Electromagnetic induction.
B. Induced currents.
C. Self-induction.
D. Mutual induction.

VIII. Electric Generators and Motors:

A. Basic principles.
B. Direct current generators.
C. Alternating current generators.
    1. Frequency.
    2. Properties.
    3. Advantages.
D. Rotary converters.

IX. Transformers and Coils:

PRINCIPLES OF X-RAY GENERATION P. 7

A. Construction.
    1. Ratio.
    2. Open core.
    3. Closed core.
B. Principle.
    1. Mutual induction.
    2. Flux.
C. Purpose.
    1. To change voltage.
D. Efficiency.
E. Types.
    1. Step-down (filament transformer).
    2. Step-up (high tension transformer).
        a. Grounded at mid point.
    3. Autotransformer (voltage selector).
F. Line voltage compensator.
G. The choke coil.
    1. Principle.
    2. Use as current regulating device.

X. Rectification:

A. Purpose.
B. Self rectification.
C. Valve tube rectification.
    1. Half wave.
    2. Full wave.
D. Construction of valve tubes.
    1. How they resemble x-ray tubes.
    2. How they differ from x-ray tubes.

XI. The X-ray Tube:

PRINCIPLES of X-RAY GENERATION p. 3-5

A. History and evolution.
    1. Crookes tubes—gas or ionic tubes.
B. Hot filament cathode.
    1. Principle of thermionic emission.
    2. Method of focusing the cathode stream.
    3. Efficiency.
    4. Filament characteristics.
        a. Voltage.
        b. Amperage.
C. Line focus tubes.
    1. Principle and advantages.
        a. Actual and effective focal spots.
    2. Anode and target materials.
    3. Effect of focal spot size on tube capacity and rendition of detail.
    4. Double focus tubes.
    5. Measuring focal spot size.
D. Rotating anode tubes.
    1. Principle.
    2. Construction.
    3. Advantages.
    4. Tube housings.
        a. Shock proofing.
        b. Ray proofing.
        c. Cooling.
    5. Focal spot sizes.
E. Therapy tubes.
    1. Types.
    2. Cooling methods.
F. General.
    1. Space charge effect.
    2. Saturation current.
    3. Saturation voltage.
    4. Anode heel effect.
    5. Stabilizers.

XII. The Typical X-Ray Circuit:

A. Primary circuit.

B. Secondary circuit.

C. Filament circuit.

D. High tension distribution (shock-proof cables).

E. The x-ray control panel.

1. Measuring instruments and the purpose of each.
    a. Line voltage indicator and compensator.
    b. Autotransformer control.
    c. Kilovolt meters (prereading).
    d. Filament regulator, filament ammeter.
    e. Milliammeters, milliampere-second meter (ballistic).
    f. Focal spot selector, circuit breaker, etc.
    g. Timers: hand, synchronous, electronic, impulse, integrating.
2. Remote control devices.

XIII. X-Rays:

A. Electromagnetic radiation.

1. Spectrum.
    a. Radio waves.
    b. Infra-red waves.
    c. Visible light.
    d. Ultra violet light.
    e. X-rays.
    f. Gamma rays.
    g. Cosmic rays.

B. Conditions necessary for the production of x-rays.

C. Detection of x-rays.

1. Films.
2. Fluorescent screens.
3. Ionization instruments.
4. Other.

D. Dual nature of x-rays.

1. Waves.
    a. Wavelength.
    b. Frequency.
2. Photons.
    a. Corpuscular.

E. Classification of x-rays.

1. Primary radiation.
    a. Primary rays from sudden stoppage of electrons.
    b. Characteristic radiation emanating from target metal itself.

2. Secondary and scattered radiation.
    a. Electrons dislodged from atomic orbits by collision.
        1) Photoelectrons.
        2) Compton or recoil electrons.
    b. Secondary and scattered x-rays.
        1) Unmodified scatter.
        2) Characteristic radiation.
        3) Modified scatter.
3. Remnant radiation.
    a. Effect upon film.

F. Measurement of x-rays.
1. Quantity.
    a. Roentgen.
2. Quality (KVP and filtration).
    a. Ångstrom unit.
    b. Half value layer.

G. Properties of x-rays.
1. Direction and speed.
2. Differential absorption by matter.
3. Photographic effect.
4. Fluorescent effect.
5. Physiological effect.
6. Ionizing effect.
7. Other.

XIV. Types of X-Ray Machines:

A. Size.
B. Capacity.
C. Line voltage and current supply.
D. Method of rectification.
E. Types of x-ray tubes used.
F. General arrangement and location of different parts.
G. Accessory equipment.
H. Discuss.
1. Fluoroscopic units.
2. Small portable and dental units.
3. Self-rectified equipment up to 100 MA.
4. 200 MA, 300 MA and 500 MA full wave generators.
5. Superficial therapy equipment.
6. Deep therapy equipment.
7. Supervoltage therapy equipment.

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Chapter VIII

DARKROOM CHEMISTRY & TECHNIQUE

OBJECTIVES:

To develop the knowledge and skills necessary for thorough and efficient darkroom procedure.

To study the history and development of x-ray film and darkroom accessories.

To gain a thorough knowledge of the chemical constituents of processing solutions and their functions.

To appreciate various types of darkroom and processing apparatus.

METHOD OF TEACHING: Lecture, demonstration, visual aids.

THEORY CLOCK HOURS: Ten hours.

TIME: First year, first semester.

INSTRUCTOR: Chief technician or other qualified instructor.

I. Need of good darkroom procedures and necessity for proper darkroom construction:

A. Radiography begins and ends in the darkroom.
   1. Keeping darkroom on a par with the rest of the department.
   2. Importance of darkroom cleanliness.
   3. Arrangement of processing and accessory equipment for efficient working.

B. Darkroom construction and equipment.
   1. Size.
   2. Light proof entrance, maze, double doors.
   3. Construction of walls for protection against chemicals and radiation.
   4. Color schemes.
   5. Water-proofing of floors.
   6. Loading bench design.
   7. Darkroom illumination.
      a. Test for safe illumination.
      b. Types of filters for safe light.
   8. Ventilation.
   9. Arrangement of drying cabinets in darkroom or in adjoining room.
   10. Accessories; storage, shelves, hangers and racks, water temperature control, thermometer, timers, pass box.

11. Film bins.
    a. Magnetic interlocks for film bins and doors.

II. Photographic Process:

A. Fundamentals.
   1. Light sensitive salts of silver.
   2. Nature of photographic emulsion.
   3. Gelatin as a suspension medium.
   4. Glass, cellulose and paper as a base.
   5. Formation of latent image on exposure.
   6. Need for chemical development.

B. X-Ray film.
   1. Types of base, i.e., cellulose nitrate and acetate, clear, tinted.
   2. Substratum coating, reason for double-coating.
   3. Characteristics of screen and non-screen type film.
   4. Dental film, miniature film.
   5. Storage of unexposed film.

C. Handling of x-ray film.
   1. Removal of film from cassettes.
   2. Photographing identification data on films.
   3. Placement on hanger.
   4. Placement in solutions.
   5. Principles of adhesion and cohesion.
   6. Removing of film from solution.
   7. Removal of film from cardboard folder.
   8. Placement of film in cassette.
   9. Placement of film in cardboard folder.
   10. Handling of film on wet side of darkroom.
       a. Placing films in dryer.
       b. Removing from dryer.
       c. Trimming corners.

III. The Developer:

A. Function of developer.

B. Chemicals.
   1. Metol and elon reducing agents.
   2. Hydroquinone—reducing agent.
   3. Sodium carbonate and sodium hydroxide—alkalies.
   4. Sodium sulphite—preservative.
   5. Potassium bromide—restrainer.

C. Effect of temperature on development rate and life of solution.
   1. Standard development, time and temperature.

D. Exhaustion of developer.

E. Replenishment.
   1. Replenisher method.
   2. Exhaustion method.

IV. Rinsing:

A. Purpose and methods of rinsing.
    1. Short stop bath.

V. Fixer or Hypo:

A. Function of fixer.
B. Chemicals.
    1. Sodium thiosulphate—clearing agent.
    2. Acetic and sulphuric acids—neutralizers.
    3. Sodium sulphite—preservative.
    4. Potassium and chrome alum—hardners.
C. Fixing time.
D. Exhaustion of fixer.

VI. Washing:

A. Purpose and methods of washing.

VII. Drying:

A. Methods of drying films.
    1. Rack.
    2. Electrical dryer.
    3. Chemical dryer.

VIII. Preparation of Solutions:

A. Suitable water supply.
B. Suitable materials for mixing vessels.
C. Order of mixing processing solutions.
D. Storage of dry chemicals and solutions.
E. Necessity for temperature control.

IX. Types and Care of Processing Apparatus:

A. Suitable materials for processing tanks.
B. Conventional large tanks.
C. Small (dental) tanks.
D. Thru-wall units.
E. Tray processing.
F. Automation units.
    1. Pako type.
    2. X-Omat type.

X. The Theory of the Photographic Process:

A. The latent image.
B. Density and gamma.
    1. The H & D curve.

C. Emulsion characteristics.
    1. Contrast.
    2. Speed.
    3. Latitude.
    4. Resolution.
    5. Evaluation tests for contrast, speed, latitude, etc.

XI. Reduction of Over Exposed Radiographs:

A. Farmer's reducer.
B. Other reducers.

XII. Film Artifacts and Their Causes:

A. Fog.
    1. Light.
    2. Chemical.
    3. Age.
B. Stains.
C. Airbells.
D. Blistering.
E. Streaks.
F. Crescent marks.
G. Reticulation.
H. Static marks.
I. Mottle.
J. Abrasions.
K. Frilling.
L. Other artifacts.

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7. **The Fundamentals of X-Ray and Radium Physics;** Joseph Selman, M.D., Published by Charles C. Thomas, 2nd Edition, Springfield, Ill.
8. **Principles of Radiographic Exposure and Processing;** Arthur W. Fuchs, Published by Charles C. Thomas, Springfield, Ill.
9. **Fundamentals of Photographic Theory;** T. H. James, George C. Higgins, Published by Morgan and Morgan, New York.

Chapter IX

PRINCIPLES OF RADIOGRAPHIC EXPOSURE I

OBJECTIVES:

To give the student a thorough understanding of the theory of x-ray technique and to correlate this knowledge with practical application, thus developing a thinking technician capable of devising a technique based on sound principles and practices.

METHOD OF TEACHING: Lecture, demonstration, discussion, visual aids.

THEORY CLOCK HOURS: Twenty hours. Ten each semester.

TIME: First year. First and second semester.

INSTRUCTOR: Chief technician or other qualified technician.

I. Radiographic Arithmetic:

A. Fractions and decimals.
B. Percentage.
C. Ratio and proportions.
D. Square root.
E. Equations.
F. Graphic presentations.
G. Use of prepared calculators.

II. Formation of the Latent Image:

A. Effects of radiation and light on emulsion.
   1. Sensitized specks.
   2. Stimulation of silver bromide crystals.
   3. Absorption with resultant ionization.
   4. Developmental centers.

III. Intensifying and Fluoroscopic Screens:

A. History and characteristics.
B. Fluorescence and phosphorescence.
C. Spectral emission of various phosphors.
D. Types.
   1. Fluoroscopic screens.
   2. Intensifying screens.
   3. Photoradiographic screens.
E. Construction.
   1. Phosphor layer.
   2. Backing.

3. Protective coating.
4. Edge seal.

F. Classes of intensifying screens.
1. Slow speed screens.
2. Medium speed screens.
3. High speed screens.
a. Effect of crystal size on rendition of detail.
b. Effect of dyes on rendition of detail.
4. Intensification factors of various speed screens.
5. Effect of screen temperature upon speed.

G. Care and mounting of intensifying screens.

H. Test to demonstrate screen artifacts.

I. Test to demonstrate poor screen contact.

IV. The Prime Factors of Radiography:

A. Photographic effect (P.E.).
1. Define and discuss.

B. Milliamperage.
1. Definition.
2. Effect of milliamperage on film (Quantitative factor).

C. Time.
1. Definition
2. Effect of exposure time on film (Quantitative factor).

D. Milliampere-seconds.
1. Definition
2. Effect of MAS on film (Quantitative factor).

E. Distance.
1. Definition
2. Inverse square law (illustrate by model and problems).

F. Kilovoltage.
1. Definition
2. Principal qualitative factor.
3. Effect upon wavelength.
4. Discussion of absorption of x-rays by various substances.
5. Effect upon radiographic latitude.

G. Photographic effect formula.
1. Definition
2. P. E. $\frac{MA \times S \times KVP^{(5)}?}{D^2}$
3. Limitation of formula.

V. Factors Affecting Radiographic Quality:

A. Density.
1. Definition of density (P.E.).
2. Characteristic curve (H&D).

3. Effect of MA and Time (MAS).
4. Effect of kilovoltage (KVP).
5. Radiation absorbed by part being examined.
    a. Quality of radiation.
    b. Thickness and structure of part being radiographed.
6. Effect of focal-film distance.
7. Effect of film screen speed combination.
8. Effect of cones, grids and bucky diaphragms.
    a. Secondary and scattered radiation.
9. Effect of development.
10. Effect of fog.
    a. Safelight.
    b. Age.
    c. Chemical.
11. Effect of respiration.
12. Effect of compression.
13. Effect of pathology.
14. Effect of filters.

B. Detail.
1. Sharpness or definition.
    a. Importance of focal spot size.
    b. Effect of object-film distance.
    c. Influence of focal-film distance.
    d. Motion unsharpness.
        1) Exposure time.
    e. Effect of intensifying screens.
    f. Effect of poor screen-film contact.
    g. Effect of film resolution.
2. Visibility of detail.
    a. Density.
    b. Contrast.
        1) Effect of fog.

C. Contrast.
1. Definition of contrast.
    a. Long scale contrast.
    b. Short scale contrast.
2. Effect of kilovoltage.
3. Effect of milliampere-seconds.
4. Effect of cones, grids and bucky diaphragms.
5. Effect of intensifying screens.
6. Effect of relative tissue absorption.
    a. Opaque-translucent media.
    b. Tissue density—subject contrast.
7. Effect of developer.
    a. Formula.
    b. Time.

8. Inherent contrast of certain emulsions.
9. Effect of filtration.
10. Effect of abdominal compression.

D. Magnification.
1. Definition.
2. Effect of object-film distance.
3. Effect of focal-film distance.
4. Method of estimating percentage of magnification.
5. Deliberate employment of magnification.
a. Fractional focal spot techniques.

E. Distortion.
1. Definition.
2. Geometry of image formation.
a. Alignment of central ray, object and film.

VI. Calibration:

A. Sphere gaps.
B. The penetrometer.
C. Value of calibration.
1. To determine correct autotransformer settings.
2. To determine the efficiency of the x-ray transformer.
3. To calibrate the radiographic output of one machine against another.
4. Calibration of exposure timers.
a. Use of the spinning top to count impulses.
1) With half wave equipment.
2) With full wave equipment.

VII. Tube Rating Charts:

A. Purpose.
B. Instantaneous ratings.
C. Anode thermal characteristics.
1. Heat units (KVP x MAS).
D. Housing cooling charts.
E. Filament increment curves.

VIII. Conditions Influencing Choice of Exposure Factors:

A. Bodily habitus.
1. Hypersthenic.
2. Sthenic.
3. Hyposthenic.
4. Asthenic.
B. Age.
C. Thickness of part.
D. Effect of disease or atrophy.
E. Erect and horizontal position differences.
F. Phase of respiration.

G. Contrast media considerations.
H. Presence of splints, plaster, dressing, etc.

IX. Filters:

A. Inherent.
B. External.
C. Material used.
D. Effect on quality of x-ray beam.
E. Protection to patient.
F. Compensating filters.

X. Grids:

SELMAN pp-253-66
FUNDAMENTALS p-24
WESTINGHOUSE p. 11-12
GRID RATIO IN RADIOGRAPHY ARTICLE
BOOKLET

A. Definition and applications.
B. Construction.
C. Types.
    1. Focused.
    2. Parallel.
    3. Cross-hatch.
    4. Rhombic pattern.
D. Moving grids (Potter Bucky Diaphragm).
    1. Single stroke.
    2. Reciprocating.
    3. Reciprocatic (high speed).
E. Grid ratio.
F. Grid radius (focus).
G. Lines per inch.
H. Grid factors.
I. Effect upon contrast.
J. Causes of grid lines.

XI. Cones, Cylinders and Diaphragms:

A. Purpose.
B. Construction.
C. Calculation of field covered.
D. Types.
    1. Fixed aperture.
    2. Variable aperture.
    3. Collimators.
E. Effect upon contrast.

XII. Calipers:

A. Description.
B. Use.
    1. Importance of standardized measuring technique.

XIII. Cassettes and Film Holders:

A. Description.
B. Use.

XIV. Technique Charts:

A. Purpose.
B. Types of charts.
    1. Variable tissue thickness chart.
    2. Optimum kilovoltage chart.
    3. High kilovoltage techniques.
    4. Advantages and disadvantages of each.
C. Technique conversions.

XV. Stereoscopy:

A. Physiological principles.
B. Geometric principles.
C. Correct placement of films.
D. Calculation of tube shift.
E. Stereoscopes.
    1. Types.

XVI. Identification Systems:

A. Lead markers.
B. Photographic identification.
C. X-Ray identification.
D. Advantages and disadvantages of each.

REFERENCES

1. **Principles of Radiographic Exposure and Processing;** Arthur Fuchs, Published by Charles C. Thomas, Springfield, Illinois.
2. **Formulating X-Ray Technics;** John B. Cahoon, R.T., Published by Duke University Press, Durham, North Carolina.
3. **Roentgenological Technique;** L. R. Sante, M.D., Published by Edwards Brothers, Inc., Ann Arbor, Michigan.
4. **Medical Radiographic Technique;** Glenn Files, Published by Charles C. Thomas, Springfield, Illinois.
5. **Fundamentals of Roentgenographic Techniques;** Joseph F. Roderick, R.T., The American Society of X-Ray Technicians Refresher Course Booklet, The American Society of X-Ray Technicians.
6. **Characteristics and Applications of X-Ray Grids;** Liebel-Flarsheim Company, Cincinnati 15, Ohio; January 1958, Free booklet.
7. **X-Ray Screens;** United States Radium Corp., Radelin Division, Morristown, New Jersey; Free booklet.

Chapter X

RADIOGRAPHIC POSITIONING

OBJECTIVES:

To provide instruction in the roentgenographic positioning of the structures and organs of the body.

This course should provide precise and detailed information on the various positions and should be supplemented with practical instruction and application in the radiographic room.

The program of instruction should be carefully correlated with the course in anatomy and students should not be given more material at each session than they can assimilate.

It is recommended that a discussion of the fundamental principles of positioning precede the demonstration. Show the necessity for different views to maintain correct detail and proportion of parts, and their projection on a plane to avoid magnification, distortion, superimposition of structures, etc.

Note 1: Under the chapter on "Procedures Using Contrast Media" and "Special Radiographic Procedures," the positioning of the more complicated examinations is given.

Note 2: Technique, where mentioned, refers to the position of the patient, the relative position of the tube to the patient and film, and to the exposure factors.

Note 3: The positioning for each area of the body is divided into two sections A and B.

Section A: Should be taught to the student in the first year and should include the basic routine views used in the department.

Section B: Should be presented in the second year after the student has become, with practice, familiar with the basic views and can appreciate their limitations and the advantage of special views to demonstrate various anatomical parts. Certain positions listed in this section may have been previously covered in section "A" if they are part of the departmental routine.

METHOD OF TEACHING: Lecture, demonstration, discussion; use of manikin, loose bones and radiographs.

THEORY CLOCK HOURS: Section A: Thirty hours. Fifteen hours, first semester — first year. Fifteen hours second semester—first year. **Section B:** Thirty hours. First semester — second year.

INSTRUCTOR: Chief or other qualified technician.

I. Nomenclature of Positioning:

A. The planes of the body.
   1. Sagittal plane (median).
   2. Coronal plane (frontal).
   3. Transverse plane (horizontal).
   4. Basic radiographic lines.

B. Terminology of x-ray projection.
   1. Anterior, posterior.
   2. Lateral.
   3. Oblique.
      a. R. A. O.
      b. L. A. O.
      c. R. P. O.
      d. L. P. O.
   4. Caudal, cephalad.
   5. Tangential.
   6. Decubitus.
      a. Lateral.
      b. Dorsal.
   7. Supine, prone.
   8. Upright.
   9. Trendelenberg.
   10. Transabdominal

OSSEOUS SYSTEM

I. Upper Extremity:

A. Technique for hand, thumb, wrist, forearm, elbow joint, humerus.
B. Technique for special views of above, including the scaphoid, carpal canal, coronoid process of the elbow, the head of the radius, erect and lateral projections of the elbow and humerus, examination of fractures where there is limitation of motion, etc.

II. Shoulder Girdle:

A. Technique for shoulder joint, clavicle and scapula.
B. Technique for special views of the acromioclavicular articulation, sternoclavicular joint, axial view of the clavicle, infraspinatus and subscapularis insertions, corocoid process, glenoid fossa, bicipital groove, transthoracic and axial projections of the upper humerus.

III. Lower Extremity:

A. Technique for toes, foot, tarsus, ankle, leg, knee, femur (lower 2/3).
B. Technique for special view of the above including metatarso-phalangeal joint, calcaneous, amputated foot view, tibio-fibular articulations, internal and external malleolus, tibial tubercle, meniscus (semilunar cartilages), patella, intercondyloid space. The use of a graduated filter in foot radiography. Problems in radiographing fractures of the lower extremity.

IV. Hip Joint and Upper Femur:

A. Technique for hip joint, acetabulum, neck of femur, upper third of femur.
B. Lateral views for hip nailing, use of curved cassette, use of protractor and other hip joint localizers. Friedman, Hsieh and Hickey positions.

V. Pelvic Girdle:

A. Techniques for pelvis, ilium, ischium, pubis, sacroiliac joints.

B. Axial projection of pubis, oblique ilium, oblique supine projection of sacroiliac joints. Erect weight-bearing views to demonstrate sacroiliac movement. Most useful views to demonstrate fractures of pelvis.

VI. Cervical Spine:

A. Technique for atlas and axis, and cervical vertebrae.

B. Special views of this area; moving jaw, oblique and body section radiography of the atlas and axis. A. P. and P. A. projections of the odontoid process, oblique views of the intervertebral foramina, lateral supine examination; semi-axial view for facets; handling of suspected fracture cases.

VII. Cervico-thoracic and Thoracic Spine:

A. Technique for cervico-thoracic region, thoracic vertebrae.

B. Fletcher's position with variations for bodily habitus; views for apophyseal articulations and spinous processes; technique for patients with marked kyphosis.

VIII. Lumbar Spine, Sacrum and Coccyx:

A. Technique for lumbar vertebrae, lumbosacral articulation, sacrum, coccyx.

B. Views for apophyseal articulation (facets), to demonstrate disc herniation, rigidity of spinal fusion, scoliosis series; posterior-anterior, oblique and axial projections of lumbosacral articulation.

IX. Bones of the Thorax:

A. Technique for sternum, ribs, (upper and lower), cervical ribs.

B. Shallow breathing and body section technique of the sternum; projection for costal joints.

X. Skull:

Planes of projection.

1. Median plane.
2. Interpupillary line.
3. Glabellomeatal line.
4. Canthomeatal line. (Radiographic Base Line)
5. Infra-orbitomeatal line. (Reid's Base Line)
6. Acanthiomeatal line.

A. Technique for cranium; general, frontal, parietal, occipital bones, cranial base, sella turcica.

B. Techniques for special views of the skull, dorsum sella, foramen magnum, foramen ovale, foramen spinosum, foramen lacernum; petrous pyramids, orbits, orbital fissure, optic foramen.

XI. Facial Bones:

A. Technique for facial bones; general, zygomatic bones, maxillae, mandible, temporo-mandibular joint, nasal bones.

B. Technique for special views of the zygomatic arch, styloid process, facial profile, projections for symphysis, body, ramus, and condyle of the mandible, A. P. projection of the condyles of the mandible, views to demonstrate lateral or medial displacement of mandibular fractures, body section radiography of the temporo-mandibular joint. Use of occlusal films with standard radiographic equipment to demonstrate pathology and fractures of the maxillae and mandible and for lateral and axial projections of the nasal bones. Reverse projections of all facial bones for use with severely injured patients who must remain supine.

XII. Paranasal Sinuses:

A. Technique for maxillary, ethmoidal, frontal, sphenoidial sinuses. Demonstration of fluid levels.

B. Non-routine views of the paranasal sinuses.

XIII. Mastoids:

A. Techniques for mastoids. (routine)

B. Technique for special views of the mastoid process; mastoid tips, petrous portion of the temporal bone, fronto-occipital, axial, Stenvers, Mayer.

XIV. Thoracic and Abdominal Viscera:

General considerations: anatomical outline, subject types, variation of organ positions with respiratory movement and change of posture, displacement in pathological conditions, exposure factor variation in relation to thickness, optimum distance and exposure variations of abnormal and difficult subjects, use of compensating filters, demonstration of fluid levels, differentiation of abnormal shadows, soft tissue technique.

THORACIC CONTENTS

A. Technique for trachea, lungs, views for apices, mediastinum, diaphragm and subdiaphragmatic conditions. Erect, supine and decubitus posture relative to fluid levels. Postures for interlobar effusion. Techniques for foreign bodies, pneumothorax, emphysema. Technique for the heart and aorta. Opaque meal for relationship to esophagus.

B. Technique for body section radiography of nasopharynx, larynx, trachea, parenchyma of the lung for cavities and tumor masses. Technique to demonstrate calcified valves. (Bronchography is discussed under "Common Radiographic Procedures Using Contrast Media.") (Cardioangiography is discussed under "Special Radiographic Procedures.")

ABDOMINAL CONTENTS

A. Technique for liver, spleen, kidneys, bladder, diaphragmatic hernia, abdominal aorta, sinuses and cavities, free gas and fluid levels.

B. Hepatosplenography, abdominal aortography, pelvimetry, uterosalpinography and retroperitoneal pneumography are covered under the chapter on "Special Radiographic Procedures." (The gastro-intestinal tract, the biliary tract and the urinary and genitourinary tract are covered in the section on "Common Radiographic Procedures Using Contrast Media.")

XV. Ductless Glands:

A. Technique for examination of the pineal body, hypophysis (pituitary gland), suprarenal glands, thyroid and parathyroid glands.

XVI. Salivary Glands:

A. Technique for demonstration of calculi in parotid, submaxillary and sublingual glands or ducts.

XVII. Soft Tissue Radiography:

A. Technique for the female breast, foreign bodies, soft tissue calcification, sinuses and fistulae, adenoids and nasopharynx.

REFERENCES

1. **Atlas of Roentgenographic Positions;** V. Merrill, Published by C. V. Mosby Company, St. Louis, Missouri.
2. **Positioning in Roentgenography;** K. C. Clark, Published by Grune & Stratton, Inc., New York, N. Y.
3. **Manual of Roentgenological Technique;** R. L. Sante, M.D., Published by Edwards Brothers, Inc., Ann Arbor, Mich.
4. **Normal Radiographic Anatomy;** I. Meschan, M.D., Published by W. B. Saunders Company, Philadelphia, Pa.
5. **Medical Radiographic Technic;** Glenn W. Files, Published by Charles C. Thomas, Springfield, Ill.
6. **Fundamentals of Teaching Roentgenographic Positioning;** Meredith G. Lewis, R.T., Published by The American Society of X-Ray Technicians, Refresher Course Booklet.

Chapter XI

MEDICAL TERMINOLOGY

OBJECTIVES:

To master medical terminology as applied to the specialty of radiology; specifically to learn anatomical names of bones and organs of the body and other anatomical descriptive terms; to learn radiographic terms and their common abbreviations; to learn commonly used medical terms, prefixes and suffixes; to understand the meaning of such terms and their proper usage.

It is suggested that during the first six months of training, each student be required to familiarize himself with approximately fifty words per week. The glossary in Sante's Manual lends itself well to this approach, since each page lists approximately fifty words. Students may also study words, prefixes and suffixes in the other books listed below and in medical dictionaries. Spelling and meanings may be checked by a short weekly examination of ten representative words selected from each page of Sante's Manual.

The glossary in Sante's Manual provides sufficient material if covered at the rate of one page each week to fill the first semester. Each week, at the time the assignment is given, the instructor should go over the unfamiliar terms and explain in greater detail than is given in the glossary their meaning and significance.

REFERENCES

1. **Manual of Roentgenological Technique;** L. R. Sante, M.D., Published by Edwards Brothers, Ann Arbor, Michigan.
2. **Medical Radiographic Terminology;** Helen M. Rose, R.T., Published by Edwards Brothers, Ann Arbor, Michigan.
3. **Medical Terminology Made Easy;** JeHarned, R.N., R.R.L., Published by Physicians' Record Co., Chicago, Illinois.

Chapter XII

COMMON RADIOGRAPHIC PROCEDURES USING CONTRAST MEDIA

OBJECTIVE:

To acquaint the student with the common procedures in radiography involving the use of contrast media, the equipment and media used, and the reactions and contra-indications to these media.

NOTE: It is suggested that selected radiographs supplement an anatomical review of the systems to be examined, prior to a consideration of radiographic procedures and techniques. A correlation of radiographic anatomy with students' general knowledge of anatomy and physiology should contribute to the intelligence with which these procedures are approached.

METHOD OF TEACHING: Lecture, demonstration, discussion, visual aids.

THEORY CLOCK HOURS: Eight hours.

TIME: First year, second semester.

INSTRUCTOR: Qualified technician and radiologist.

I. General Characteristics of Contrast Media:

A. Basic principles.
B. Forms of media.
  1. Radiolucent.
    a. Oxygen.
    b. Nitrogen.
    c. Helium.
    d. Carbon dioxide.
    e. Air.
  2. Radiopaque.
    a. Iodized oils.
    b. Organic soluble iodides.
    c. Inorganic iodides.
    d. Colloidal suspensions.
    e. Metallic salts.
    f. Others.
C. Characteristics of a good medium.
D. Systemic reactions to media.
E. Precautions in the preparation and administration of media.
F. Some organs or systems in which opaque media are used.

II. Gastrointestinal Tract:

A. Anatomy of the G. I. tract. (review)
B. Examination of the upper gastrointestinal tract.
  1. Preparation of the patient.

2. Opaque media used.
    a. Barium.
    b. Iodized oil.
    c. Rugar.
    d. Aqueous organic iodides (Gastrografin)
3. The esophagus, positioning and technique.
4. The stomach, positioning and technique.
5. Small intestine.
    a. Barium meal.
    b. Gastrografin.
    c. Small bowel enema.

III. The Colon:

A. Anatomy. (review)
B. Preparation of the patient.
    1. Barium enema.
    2. Double contrast enema.
    3. Gastrografin enema.
    4. Use of tannic acid, etc.
C. Preparation of media.
D. Equipment used.
    1. For the regular barium enema.
    2. For the double contrast enema.
E. Special considerations with infants and children.
    1. Normal saline base.
    2. Equipment.
    3. Low pressure.
F. Contraindications.
G. Positioning and technique.
    1. Barium enema.
    2. Double contrast enema.
H. Stereoscopic films of the colon.

IV. Biliary Tract:

A. Anatomy and physiology. (review)
B. Opaque medium used.
C. Oral cholecystography.
    1. Preparation of the patient.
    2. Contrast media employed.
    3. Positioning and technique.
    4. Post fatty meal radiography.
D. Oral cholangiography.
    1. Indications and physiology.
    2. Purpose of increased dosage.
    3. Purpose of fatty meal.

4. Positioning of patient. (supine oblique)
5. Interval of exposures.

E. Post-cholecystectomy oral cholangiography (Twiss Method).
1. Preparation of the patient.
2. Administration of contrast material (Telepaque).
3. Purpose of paregoric.
4. Positioning and technique.

F. Intravenous cholangiography and cholecystography.
1. Usual indications and contra-indications.
2. Preparation of patient.
3. Sensitivity tests.
4. Positioning and technique.
5. Use of body section radiography.

G. Post-operative cholangiography.
1. Indications.
2. Equipment needed.
3. Opaque media used.
4. Method of injection.
5. Position of the patient and the technique.

H. Operative cholangiography.
1. Surgical procedure.
2. Use of bantam Potter-Bucky or stationary grid.
3. Positioning of the grid and patient before surgery begins.
4. Method of injection.
5. Method of suspending respiration during exposure.
6. Radiographs taken and technique used.

V. Urinary Tract—Excretory Method (IVP):

A. Anatomy and physiology. (review)

B. Purpose of the examination.

C. Preparation of the patient for the procedure.
1. Before the examination.
2. At the time of the examination.
3. Sensitivity tests.

D. Equipment needed.

E. Contraindications.

F. Patient reaction to media.

G. Discuss other, less common methods.
1. Oral.
2. Subcutaneous.
3. Intramuscular.
4. Special considerations in infants and children.
a. Use of carbonated beverages to distend the stomach in infants.

H. Positioning and technique.
    1. Patient lying.
    2. Patient upright.
    3. Time lapse between exposures.
    4. Marking the radiographs.
        a. Time.
        b. Position.
    5. Use of compression.
    6. Gonadal shielding.

I. Nephrograms.

VI. Urinary Tract—Retrograde Method:

A. Purpose of the procedure.
    1. Structural visualization.
    2. Can be a functional examination (PSP injection).

B. Meaning of terms.
    1. Pyelogram.
    2. Ureterogram.
    3. Pyeloureterogram.
    4. Urogram.

C. Preparation of the patient.
    1. Before the examination.
    2. At time of the examination (draping, etc.).

D. Equipment needed.

E. Media used.

F. Gonadal protection.

G. Positioning and technique.
    1. Patient lying.
    2. Patient upright.
    3. Tube shift, oblique and lateral views for differentiation of calculi.

VII. Urinary Tract—Cystography and Urethrography:

A. Cystography.
    1. Purpose of the procedure.
    2. Equipment needed.
    3. Preparation of the patient.
    4. Media used.
        a. Solutions.
        b. Air (pneumocystography).
    5. Positioning and technique.

B. Urethrography.
    1. Purpose of the procedure.
    2. Equipment used.
    3. Preparation of the patient.

4. Media used.
5. Positioning and technique.

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1. **Patient Care and Special Procedures in X-Ray Technology;** Vennes and Watson, Published by C. V. Mosby Company, St. Louis, Mo.
2. **An Atlas of Normal Radiographic Anatomy;** Isadore Meschan, M.D., Published by W. B. Saunders Company, Philadelphia, Pa.
3. **Formulating X-Ray Technics;** John B. Cahoon, R.T., Published by Duke University Press, Durham, N. C.
4. **Manual of Roentgenological Technique;** L. R. Sante, M.D., Published by Edwards Brothers, Ann Arbor, Michigan.
5. **Special Radiographic Techniques;** R. J. Bannister, R.T., Published by The American Society of X-Ray Technicians, Refresher Course Booklet.
6. **Medical Radiographic Technic;** Glenn W. Files, Published by Charles C. Thomas, Springfield, Illinois.
7. **Atlas of Roentgenographic Positions;** Venita Merrill, Published by C. V. Mosby Company, St. Louis, Missouri.

Chapter XIII

NURSING PROCEDURES PERTINENT TO RADIOLOGY

OBJECTIVES:

To acquaint the student with nursing procedures and techniques used in the general care of the patient with emphasis on the role of x-ray technician in various nursing situations.

METHOD OF TEACHING: Lecture, demonstration, discussion, visual aids.

THEORY CLOCK HOURS: Ten hours.

TIME: First year, second semester.

INSTRUCTOR: Registered nurse and qualified technician.

I. The X-Ray Technician on the Health Team:

A. Definition of health team.
B. Responsibility imposed by health team membership.
C. Teamwork essential to accomplish ultimate aim of health team.

II. Handling of Patient:

A. Assisting patient into a chair.
B. Technique for lifting helpless patient from stretcher to table.
C. Technique for undressing ill patient or changing gown.
D. Technique for turning patient.
E. Arranging pillows and comfort.
F. Assisting patient in elimination of body wastes, bed pan or urinal.
G. Proper attire for x-ray examinations.
H. Care of patients personal belongings.

III. Emergency Care and Handling of Seriously Ill or Injured Patients:

A. Elements of first aid.
B. Acute abdomen.
C. Cervical spine injury.
D. Long bone fractures.
E. Skull injuries.

IV. Handling of Surgical Cases:

A. Surgical emergencies, shock, hemorrhage, collapse.
B. Effects of anesthesia.

V. Aseptic Technique:

A. Discussion of asepsis, antisepsis, sterilization, disinfection.
B. Handling of sterile articles, solutions, instruments, syringes and needles. Technique for opening sterile packs.
C. Methods of sterilization.
D. Gown technique.

VI. Management of Emergencies in a Radiology Department:

A. Whom to call and when.
B. Equipment and drugs on hand.
C. "What to do until the doctor comes."

VII. Common Splints and Bandages:

VIII. Principles of hypodermic, subcutaneous, intramuscular and intravenous injections and tray set-up for each type of injection.

IX. Procedure for Administration of Enemas:

A. Types of enemas, basic principle.
B. General instructions to patient.
C. Tray requisites.
D. Use of normal saline, especially in young children.
E. Use of tannic acid.
F. Technique of administration.
G. Care of rubber tubing enema nozzles, Bardex tube, glass connectors.

X. Directions for Cleansing Enema for Urography, Cholecystography, Barium Enema and the Abdominal Viscera:

(The enema should consist of 1½-2 quarts of plain warm water. Let all air out of the rubber tubing and catheter by raising the enema can and allowing some of the water to pass out through the catheter before pinching it off and inserting it into the patient's rectum.

Have the patient lie on his left side, knees flexed, the right knee more than the left. Do not raise the enema can more than two feet above the patient, as a rapid inflow of water causes too great a dilatation of the colon and makes the patient want to expel the water immediately. Allow the water to fill the bowel slowly and evenly so as not to excite the bowel to contraction.

After the patient has taken one pint of water, have the patient **turn to the prone position for the second pint, then turn on his right side for the remainder of the enema.**

IMPORTANT: Patient should retain enema for a few minutes before going to the toilet and evacuating thoroughly.)

XI. Obtaining the Vital Signs:

A. Temperature.
B. Pulse.
C. Respiration.
D. Blood pressure.

XII. Catheterization:

A. Purpose.
B. Method.

XIII. Artificial Respiration:

A. Need for oxygen.
B. History of artificial respiration.
C. Technique of administration.
D. Provide practice for administration of artificial respiration.

XIV. Anesthesia:

A. General discussion.
B. Types permissible in x-ray.
C. Explosive types.

XV. Operating Room Radiographic Procedures:

A. Aseptic techniques.
B. Safety practices in operating room procedures.
    1. Grounding of equipment.
C. Hip nailing, intramedullary nailing, operative cholangiography.
D. Emergencies in operating room.
    1. Foreign bodies.
E. Importance of pre-established technical factors for O. R. radiography.

XVI. Bedside Radiography:

A. The orthopedic patient.
B. The critically ill patient.
C. The cardiac patient.
D. The patient in a respirator.
E. The patient receiving oxygen therapy.

XVII. Handling of Patients with Communicable Diseases:

A. Precautionary technic.
    1. Wearing of gowns and masks, and discarding technic.
    2. Contaminated areas.
    3. Hand washing.
    4. Disinfecting of x-ray equipment.

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Chapter XIV

PEDIATRIC RADIOGRAPHY

NOTE:

Pediatric Radiography is spelled out in some detail. It is a specialized field in itself, and there is universal difficulty in organizing and presenting the subject effectively. Whether the volume of pediatric radiography within any hospital is extensive or scant, the importance of adequate routines and procedures cannot be overemphasized.

Instructors will wish to make the decision as to the allocation of teaching hours for this subject. It is suggested that a minimum of eight hours be established, and that individual circumstances may indicate the desirability of increasing the allotment of time profitably spent thereafter. For those who are in a position to increase the emphasis placed upon this facet of the technological field, the comprehensive material which follows may be particularly helpful. The accessories listed, the preparation and procedures for examinations, and the routines offered are set forth as guides—they typify the modus operandi widely accepted by radiologists in the field of pediatric radiology.

METHOD OF TEACHING: Lecture and demonstration.

THEORY CLOCK HOURS: Eight hours.

TIME: First year, second semester.

INSTRUCTOR: Qualified technician.

I. Necessary Equipment and Accessories:

A. 200 to 500 full wave x-ray generator.
B. High Speed Bucky diaphragm.
C. Timer to 1/60 second.
D. 10 x 12 stationary grid or grid cassette.
E. Open end cassette tunnel.
F. Compression band.
G. "Acetabular box" for elevating the pelvis.
H. Cotton webbing straps (1 inch wide, 30 inches long).
I. Cellucotton.
    1. Inexpensive, entirely radiolucent, available in 8 lb. rolls economically.
J. Ivanhoe or other infant immobilizer device.
K. Balsa wood splint board or lucite paddle (for immobilizing extremities).
L. Sand bags of different sizes.
M. Non-stationary head immobilizers.
    1. Anaesthesia cones or masks (inflated).
    2. Giant size cellulose sponges.
    3. Ace bandage rolls.

N. Psychological aids.
   1. Fluorescent paint (in fluoroscopic room).
   2. Children's furniture and toys.
   3. Lollipops.

II. It is important that the technician have a definite method of procedure with young children. Its advantages include the saving of time, films and the energy of the operator, as well as minimizing the amount of radiation to the patient. A suggested sequence of procedure could be as follows:

A. Read requisitions carefully.
B. Bring patient into the radiographic room. Speak to the child and make every effort to gain his confidence.
C. Explain procedure simply if the patient is old enough to understand.
D. Assemble necessary equipment.
E. Set machine for first exposure.
F. Position patient.
G. Shield gonadal area.
H. Make exposure.

III. Chest:

A. Suggested positions.
   1. P. A. and lateral views, 6 ft. distance.
B. Alternate positions, with infants.
   1. A. P. view at 6 ft. distance, sitting upright.
   2. P. A. view at 3 ft. distance, recumbent.
   3. A. P. and lateral views at 3 ft. distance, recumbent.
C. Special specific positions.
   1. Left P. A. oblique.
   2. A. P. view in lateral position, grid cassette.
      a. Horizontal fluid levels.
   3. A. P. view using Bucky diaphragm.
      a. Heavy lung densities.
D. Special procedures.
   1. Heart fluoroscopy.
      a. Preparation—infants.
         1) No food or fluids for 3-4 hours.
         2) Regular formula.
      b. Preparation—children.
         1) No preparation needed.
      c. Procedure.
         1) P. A. lateral and obliques of chest at 6 ft. distance.
         2) Any specific views requested.
   2. Non-radiopaque foreign bodies in lung.
      a. Fluoroscopy is essential.
      b. Radiography.

1) A. P. or P. A. views.
a) Both inspiration and expiration, maximum.

3. Tracheograms.
a. Preparation.
1) Infants—sedation advised.
2) Childrens—general anaesthesia.
b. Procedure.
1) Operator inserts laryngoscope, patient supine.
2) Thin metal catheter passed through into trachea.
3) Contrast media injected rapidly.
4) Instruments withdrawn.
c. Radiography suggested positions in order.
1) A direct lateral, recumbent.
2) An A. P. view, recumbent.
3) Left and right A. P. oblique views.
4) Speed and team work, essential.

4. Bronchograms.
a. Preparation.
1) Selected anaesthesia.
b. Procedure.
1) Direct instillation, as tracheograms.
2) Catheter technic.
a) A small rubber or plastic catheter with syringe attached, is passed into trachea.
b) Under fluoroscopic guidance, contrast media injected into either lung.
c. Radiography.
1) As tracheograms.
2) Any additional special views needed.

IV. Neck and Cervical Spine:

A. Suggested standard positions.
1. A. P. view, using Bucky diaphragm.
2. Lateral view, sitting, at 6 ft. distance.

B. Alternate positions—infants and uncooperative children.
1. A. P. view, recumbent.
2. Lateral view, patient recumbent.
a. Child supine, C. R. horizontal, cassette perpendicular.
1) Child's head extended with webbing strap under chin.

C. Special views—cervical spine.
1. A. P. view, open-mouth, for C-1, C-2.
2. Direct lateral of neck, using Bucky diaphragm.
a. Patient in lateral position, pad under head and shoulders.
1) Object—bone definition.

D. Special procedure—tracheogram.
1. See—Chest.

V. Lumbar and Thoracic Spine:

A. Suggested standard positions.
1. A. P. and lateral views, Bucky diaphragm or grid.
a. Medium sized cassettes, carefully centered.

B. Special views.
1. "Meningoceles."
a. A. P. view, using Bucky diaphragm or grid.
1) Child's body elevated with cellucotton to prevent pressure on tumor.
a) Increased KV factors.
b. Lateral view.
c. A soft spot lateral of tumor, grid cassette.
2. The scoliosis series.
a. Necessary accessories and assistance.
1) Physician in attendance to assist with positions.
2) Seven (14 x 17) cassettes.
3) Shielding, for gonad protection.
a) Leave iliac crests uncovered, included on film.
4) Measured blocks at hand.
a) Pelvic tilt films.
b. Procedure—suggested positions.
1) A. P. and lateral of entire spine, recumbent.
2) Left and right lateral maximum bending films.
3) An A. P. view upright, standing or sitting.
4) Left and right pelvic tilt films, maximum tilt.
a) Child unsupported, if possible.
b) Note amount of lift, each side on requisition.
3. Special views—post-operative, spinal fusion patients.
a. A. P., lateral and oblique or off-lateral view.
1) Off-lateral—20° anterior, rotation from direct lateral.

VI. Skull:

A. Cranium.
1. An A. P. view, or A. P. occipital view.
2. One lateral stereo pair, or one lateral, each side.
3. P. A. view.
4. Special views.
a. A true tangential view.
1) Depressed skull fracture examination.
b. The "Hertz" or submentovertical positions.
1) Basal skull examination.

B. Sinuses.
    1. The Waters position. (modified)
        a. Patient prone, cassette angled only 15°.
    2. The frontal position.
        a. Cassete angled 15°, children.
        b. Cassette flat, little children.
            1) Uncooperative child, immobilized.
    3. Lateral sinuses and nasopharynx.
        a. Patient supine, webbing strap under chin with mouth tightly closed.
        b. Tube horizontal, cassette perpendicular.
        c. Cooperative children, exposure at passive expiration.
        d. Uncooperative children, exposure at maximum inspiration.
            1) Keep time factors at 1/60 second, if possible.

C. Mastoids.
    1. A Towne skull view.
        a. Comparison both mastoids and petrous tips.
    2. Lateral oblique views of each ear.
        a. Patient prone, cassette angled 15°.
        b. C. R. direct at center of ear.
        c. Head supported by webbing strap.
        d. Ear taped forward.

D. Cheeks.

Soft tissue radiographs are sometimes requested to discover the presence of foreign bodies or radio-opaque stones in the parotid duct.

    1. Tangential of cheek.
        a. Patient supine, head tilted 5° laterally away from side under examination, from direct A. P. view.
        b. Cardboard exposure holder used.
        c. Patient inflates cheek with air.
    2. Radiography.
        a. Technic—as for exposure of a hand.
        b. Time factors, as low as possible.

E. Nasal Bones.
    1. A "Waters" sinus view.
    2. Laterals of each side, using spot cone.
        a. Cardboard exposure holder.
            1) Children's nasal bones small and underdeveloped.
        b. Uncooperative children supine.
            1) Supported by webbing strap.

F. Optic foramina.
    1. Children prone, cassette contacts.
        a. Side of nose, malar bone, superior orbital ridge.
    2. C. R. directed at center of eye.

G. Mandibles and temporo-mandibular joints.
    1. A Towne skull view.
        a. C. R. directed at jaws.
    2. Lateral oblique views, each mandible.
        a. Patient prone, pillow under chest.
        b. Lower edge of the cassette raised 15°.
        c. C. R. directed at center mandible.
    3. Lateral obliques, temporo-mandibular joints.
        a. Patient prone, positioned as for lateral mastoid.
        b. C. R. directed at center T. M. joint.
        c. Successive exposures—mouth open and closed.
    4. Special view—symphysis of mandible.
        a. Patient supine, head tilted back.
            1) Use occlusal dental film.
            2) C. R. upwards at right angle to plane or film.

Special Procedures of Skull

I. CRANIUM—Encephalogram and Ventriculogram:

A. Preparation, sedation or anaesthesia.
B. Procedure—Encephalogram.
    1. Patient supported upright.
    2. Following spinal tap, intermittently.
        a. Fluid withdrawn in small amounts.
        b. Replaced by air.
        c. Patients head tilted in varying degrees.
            1) Proper drainage of fluid.
            2) Distribution of air evenly.
C. Procedure—Ventriculogram.
    1. Direct ventricular tap.
D. Radiography.
    1. A. P. views upright and recumbent.
    2. P. A. views.
    3. Stereoscopic laterals of each side.
    4. Any special views advised.
        a. Careful alignment and centering important.

II. CRANIUM—Intracranial Air Bubble Studies with Hydrocephalics:

A. Preparation—sedation usually adequate.
B. Procedure—direct tap.
    1. 10 cc of fluid withdrawn.
    2. Replaced with air.
    3. Total air injected—20 to 50 cc.
C. Technic—multiple positions of skull.
    1. Standard A. P. view of skull.
    2. Lateral view, patient supine.
        a. C. R. horizontal, cassette perpendicular.
    3. Lateral view, patient prone.
        a. C. R. horizontal, cassette perpendicular.

4. A. P. or lateral view upright, patient sitting.
5. Lateral view upright, patient inverted.

III. NASAL BONES—Rhinograms:

A. Preparation—none needed.

B. Procedure.
1. Patient supine.
2. Nasal catheter inserted into one nostril.
3. 5 to 10 cc of contrast media injected.

C. Radiography.
1. A lateral view of nasopharynx, C. R. directed to face.
2. An A. P. view of face, using Bucky diaphragm.
   a. A. P. view necessary to prevent spillage of contrast media.
3. Each nostril must be examined separately if both are under consideration.

VII. Upper Extremities:

A. Shoulders.
1. Suggested standard position.
   a. A. P. view of both shoulders—patient supine.
      1) Arms held in comparative position.
      2) C. R. directed to center of film.
2. Special positions.
   a. Lateral of humerus—patient supine.
      1) Arm abducted, thumb against table.
      2) Elbow flexed to 45° angle.
   b. Direct lateral of shoulder joint through axilla.
      1) Patient supine, elevated 2-3 inches above table.
      2) Patient's arm abducted.
      3) C. R. horizontal, cassette perpendicular.

B. Forearm.
1. A.P.—infants and uncooperative children.
   a. Patient supine, immobilize by holding humerus and hand —use lead rubber gloves.
2. Lateral.
   a. Elbow flexed 45°, immobilize by holding humerus and hand—use lead rubber gloves.

C. Hand.
1. P. A.—hand held by balsa board or lucite paddle.
2. Oblique. Use wad of cellucotton under hand and immobilize as in P. A. view.

VIII. Lower Extremities:

A. Pelvis and hip joints.
1. Suggested standard positions.
   a. A. P. stereoscopic pair—or one A. P. view.

b. Lateral oblique views separately or together.
    1) Patient's legs abducted with extreme rotation.
c. Lateral oblique view—both hips (one film).
    1) Advantages of this position.
        a) Patients gonads may be shielded.
        b) Comparative views obtained.
        c) Patient receives less direct radiation.

B. Non-routine positions of hip joint.
1. Direct lateral of hips, "acetabular" position.
    a. Value of acetabular box.
    b. Patient supine elevated above table top.
    c. Legs fully abducted, if possible.
    d. Cassette perpendicular against the perineum.
    e. C. R. just by-passes iliac crest.
        1) Provides information—congenital dislocation of hips.
        2) Gonadal shielding cannot be used.
2. A. P. view of hips, push-pull technic.
    a. Patient supported firmly above iliac crests.
    b. Physician grasps mid-femoral area.
    c. Pushes upward and pulls down successively.
    d. Machine ready—expose at physician's signal.

C. Knees and legs.
1. Suggested routine positions.
    a. A. P. and lateral views.
        1) Include at least one joint on all views of the legs.
2. Special views.
    a. Knees and lower extremities in P. A. position.
        1) Advantage—knees cannot be flexed—contact uniform.
    b. Supine lateral knee.
        1) Patient supine—C. R. horizontal, cassette perpendicular.
    c. Tunnel or intercondylar view of knee.

D. Feet.
1. Suggested standard position.
    a. A. P. and lateral, or oblique views of feet.
2. Special views.
    a. True lateral with maximum dorsiflexion.
        1) Club foot cases.
    b. True lateral, weight bearing.
        1) Patient stand on box.
        2) C. R. horizontal, exposure holder perpendicular.

IX. Extremities to Demonstrate Certain Diseases or Conditions:

A. Modification of long bones for:
   1. "Scurvy"—A. P. views of extremities.
   2. "Rickets"—A. P. view of one wrist—one knee.
   3. "Lead Poisoning"—A. P. views of extremities.
   4. "Congenital Lues"—A. P. views of extremities.
   5. "Anemia and Leukemia"—A. P. views of extremities.
   6. "Mongolism"—P. A. views of hands; A. P. pelvis.
   7. "Osgood-Schlatter's" disease—spot lateral of knees.
   8. "Bone-age studies"—P. A. views of hands.

B. Special views of extremities.
   1. Lateral oblique ankle position.
   2. Oblique views of carpal bones.
   3. A. P. views of elbow, patients arms in acute flexion.
      a. Position of condyles with supracondylar fractures.
   4. Direct lateral of proximal humerus.
      a. C. R. directed through chest, using grid cassette.
   5. Spot films using Bucky diaphragm.
      a. Details of bone cysts, bone tumors, etc.
   6. Orthoroentgenograms (for measurements of bone lengths).
      a. Common methods.
         1) Bell Thompson rule.
         2) Teleroentgenograms—6 ft.
      b. Positioning.
         1) Lower legs parallel; toes up.
         2) Radiographs will include hips, knees, ankles.
         3) Shield gonads.

X. Gastrointestinal Tract:

A. Abdomen.
   1. Suggested standard positions.
      a. A. P. recumbent, including diaphragms and symphysis pubis.
      b. A. P. upright, using stationary grid.
   2. Special considerations.
      a. Radio-opaque foreign bodies ingested.
         1) A. P. views of entire G. I. tract.
         2) Direct lateral, if foreign body present.

B. Abdomen for "imperforate anus"—newborn infants.
   1. A. P. views recumbent and upright.
   2. Lateral view, upright, inverted.
   3. Technical considerations.
      a. A lead marker is taped to anal dimple.
      b. Infant is inverted for several minutes prior to lateral inverted view.

1) Object-maximum, distal penetration of colonic gas.

c. No grid necessary—rapid exposure time.

d. Conclusion—if the infant's condition permits delay of surgery, inverted abdominal films may be taken four to six hours after the original set. This follow-up film often reveals a more distal penetration of colonic gas.

C. Special procedures.

1. G. I. Series—infants.

a. Preparation.

1) Food and fluid withheld three to four hours.

2) Two to four ounces U.S.P. barium sulphate mixed with sterile 5% dextrose in water.

3) Sterile nursing bottle.

4) Several sterile nipples at hand.

5) Gastrografin, or similar preparation.

a) Suspected esophogeal atresia or obstruction.

6) Protection for x-ray personnel.

a) Lead shielding for fluoroscopic table.

b) Lead aprons, lead rubber gloves, etc.

c) "Brat-board" to secure infant.

b. Procedure.

1) Fluoroscopy.

a) Infant fed radio-opaque material.

b) Supine or right lateral positions, favorable.

c. Radiography.

1) Spot films and follow-up films.

a) As suggested by radiologist.

2. G. I. Series—children.

a. Preparation, procedure, and radiography.

1) Instructions—as with adults.

3. Barium Enema.

a. Preparation.

1) A single cleansing enema one to three hours prior to the examination.

2) U.S.P. barium sulphate 50% mixed with tepid **normal saline.**

3) A soft rubber catheter, suitable enema tip.

a) Size to fit anal orifice snugly.

b) Taped to buttocks after insertion.

4) Lead shielding in place.

5) Patient secured to "brat-board" or other immobilizing device.

b. Procedure.
    1) Barium allowed to flow into colon under fluoroscopic guidance with enema can not over 36 inches high.
c. Radiography—infants and little children.
    1) Initial filled film.
        a) A. P. view using spot-film device.
    2) Post evacuation films, as requested.

XI. Urinary Tract:

A. Special procedures.
1. Intravenous urograms.
a. Preparation—infants.
    1) Fluid and food withheld four to six hours.
    2) Cleansing enema one to two hours before examination.
b. Preparation—children.
    1) Fluid and food withheld ten to twelve hours.
    2) Cleansing enema one to two hours before examination.
    3) A light dry breakfast permitted.
c. Important accessories.
    1) A table-top compression band.
    2) An arm-board to prevent flexing of an elbow.
    3) A shaving kit.
        a) Injection of scalp veins sometimes necessary.
    4) Stationary grid or a grid cassette.
    5) Carbonated beverage.
        a) To inflate stomach and produce homogeneous shadow on infants.
d. Procedure.
    1) Preliminary survey A. P. view of abdomen.
        a) Review wet by radiologist.
    2) Patient's history reviewed.
        a) To check on allergic manifestations.
    3) Test for allergy.
    4) Opaque media injected slowly, intravenously by physician.
        a) Minimum injection time advised—two minutes.
e. Radiography.
    1) Post-injection films at exactly 3, 5 and 10 minutes.
    2) Label each film with time interval.
    3) Shield pelvis on 3 and 5 minute film.

4) Uncover pelvis for last film.
    a) Examination may be terminated with normal patients.
5) Wet films reviewed by radiologist—delayed films as indicated.

2. Retrograde pylograms.
    a. Preparation—selected anaesthesia.
        1) Cleasing enema two hours before examination.
    b. Procedure.
        1) Following cystoscopic visualization, catheters are passed on into each ureter.
        2) Separate urine specimens collected.
    c. Radiography.
        1) Survey A. P. view of abdomen.
            a) Check technic, position of catheters, etc.
        2) Post-injection films, as desired by operator.
            a) Instantaneous exposure at signal.
        3) Follow-up films as needed.
        4) Final A. P. view—drainage film, after catheters withdrawn.

3. Cystogram.
    a. Preparation—usually mild sedation.
    b. Opaque media—4% sodium iodide or similar preparation.
    c. Procedure.
        1) Patient in A. P. position on the x-ray table.
        2) Patient catheterized by physician.
        3) Patients bladder emptied.
        4) Patients bladder filled with opaque media.
        5) Catheter clamped off.
    d. Radiography.
        1) A. P. and lateral films with C. R. directed at pelvis.
        2) Any follow-up films needed after review.

4. Voiding urethrogram, following cystogram.
    a. Procedure.
        1) Patient placed in either A. P. oblique position.
        2) Grid cassette placed in position.
        3) Catheter withdrawn, patient voids media.
        4) Film exposed simultaneous with voiding.
            a) Precise timing essential.

5. Retrograde urethrogram.
    a. Preparation—mild sedation.
        1) Radio-opaque media in syringe.
            a) Thixokon, Lipiodol or similar preparation.
            b) Warm Lipiodol or similar preparation.
        2) Cystoscopic tip or short catheter fixed to syringe.

b. Procedure.
    1) Patient placed in either A. P. oblique position.
    2) Grid cassette in position.
    3) Catheter inserted into meatus ½ to 1 inch.
    4) Radio-opaque material injected.

c. Radiography.
    1) Exposure timed just prior to termination of injection.
        a) Urethra shown at maximum distention.
        b) Precise timing essential.

6. Nephrostograms.
    a. Procedure.
        1) Retrograde injection of Skiodan or similar preparation.
        2) Direct injection into nephrostomy tube.

    b. Radiography.
        1) A. P. view of abdomen at termination of injection.
            a) Maximum filling of renal pelvis.
        2) Patient placed in upright sitting position.
        3) Follow-up films at hourly intervals.
            a) A demonstration of dependent drainage of either kidney.

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Chapter XV

PRINCIPLES OF RADIOGRAPHIC EXPOSURE II

OBJECTIVES:

To give the student a complete and thorough working knowledge of the manipulation of exposure factors through the completion of problems and experiments. To learn the basic principles needed to construct technique charts for all situations and all kilovoltage ranges.

METHOD OF TEACHING: Lecture, demonstration, problems, visual aids, i.e., radiographs.

THEORY CLOCK HOURS: Ten hours.

TIME: Second year. First semester.

INSTRUCTOR: Chief or other qualified technician.

I. Discussion and Problems:

A. Time-focal film distance relationship.
B. Milliamperage-focal film distance relationship.
C. Milliampere-seconds-focal film distance relationship.
D. Kilovoltage-milliampere-seconds relationship.
E. Milliamperage-time relationship.

II. Radiographic Experiments to Demonstrate:

A. Focal film distance—density relationship.
B. Time-focal film distance—density relationship.
C. Milliamperage-focal film distance—density relationship.
D. Kilovoltage-density relationship.
E. Kilovoltage-milliampere-seconds—density relationship.
F. Kilovoltage—contrast relationship.
G. Time—density relationship.
H. Milliampere—density relationship.
I. Milliampere-seconds—density relationship.

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Chapter XVI

PROTECTION TO PATIENTS AND PERSONNEL

OBJECTIVES:

To provide maximum safety to patients and personnel.

While every effort should be exerted to keep the dose of radiation to the lowest possible level to people who are well, this should be no deterrent to the use of x-rays in detecting and identifying disease processes in patients who are injured or ill, provided that this is done by physicians and technicians who are trained and experienced in making such examinations.

The decision as to the indications and necessity for x-ray examinations is an important one. This is the responsibility of the referring physician and radiologist and not of the x-ray technician.

As regards applied training in "Radiation Protection" it is suggested that students not be permitted to make x-ray exposures of patients until they thoroughly understand the general principles of protection and the operation of the equipment to be used. Emphasis should be laid upon the importance of obtaining a diagnostic radiograph at the first exposure and to avoid "re-takes."

METHOD OF TEACHING: Lecture, demonstration, discussion.

THEORY CLOCK HOURS: Ten hours.

TIME: Second year, first semester.

INSTRUCTOR: Radiologist and other qualified instructors.

I. Definition of terms employed and significance (see Table I): (It is suggested that no effort be made in this section to cover more than the broad concepts of the terms used and their implications to technicians).

A. Roentgen; milliroentgen; rem (roentgens-equivalent-man).

B. Maximum permissible dose (MPD) (see Table I).

TABLE I. RECOMMENDED MAXIMUM PERMISSIBLE DOSE (MPD) TO GONADS

1. ACCUMULATED DOSE. MPD in rems (roentgens-equivalent-man) is equal to 5 times the number of years beyond age 18, provided no annual increment exceeds 15 rems. Thus an individual from time of conception to age 18 is allowed not more than a total of 5 rems. Age 25: 35 rems. Age 35: 85 rems. Et cetera.
2. EMERGENCY DOSE. An accidental or emergency dose of 25 rems to the whole body once in a lifetime is assumed to have no effect on radiation tolerance of the individual. Note that much higher doses may be safely and usefully delivered to limited portions of the body under the controlled conditions of radiation therapy.
3. WEEKLY AND ANNUAL DOSE FOR EXPOSED PERSONNEL. For those people who are engaged in occupations involving exposures to radiation, the MPD should not exceed 0.3 rems in any single week. It is desirable, however, to keep the average dosage to about one-third this amount in order not to exceed a total of 5 rems per year.
4. MEDICAL DOSE. Radiation exposures resulting from necessary medical and dental procedures shall be assumed to have no effect on the radiation tolerance status of the person concerned.

C. Monitoring.
D. Whole body radiation; gonadal radiation.
E. Somatic; genetic; mutations.

II. Interaction of Radiation with Matter:

A. Absorption process.
B. Ionization.
C. Mechanism of biological damage.
1. Somatic effects of radiation. Most of these have been well known for many years. Suggest that these be discussed with regard to factors which produce each; dose; types and severity of lesions; and results.
a. Skin.
1) Acute radiation effects.
2) Delayed effects—inflammatory, neoplastic.
b. Lymphoid tissue; bone marrow.
c. Gonads—immediate and delayed effects on exposed persons; dose required to produce damage.
d. Embryo or foetus—risk greatest during first days and weeks of pregnancy, diminishing as pregnancy advances; dose; effects, known and theoretical.
e. Other organs.
2. Genetic effects of radiation. As outlined in December 1956 report of National Academy of Sciences.
a. The evidence to date is largely theoretical, most of it based on observations made in low forms of plant and animal life with scanty and inconclusive findings in mammalian experiments. On the basis of this evidence, however, it may be assumed that a hazard exists unless proven otherwise.
b. Radiation reaching the reproductive cells is believed to produce mutations that may be passed on to succeeding generations; there is no minimum amount of radiation which must be exceeded before mutations occur, but, the more radiation, the more mutations. Effects are cumulative and depend on the total gonad dose received from time of conception of the individual until the conception of its final offspring. Mutations may appear in first or any succeeding generation. Estimations have been made as to the amount of radiation which is apt to be genetically significant; these are reflected in "Recommended MPD." (Table I)
c. Inferences.
1) Heavy exposures involving the gonadal areas should be avoided, especially in children and adults of procreative age.

2) Greatest caution should be exerted during pregnancy, especially early stages.

3) In making x-ray examinations of infants and young children, care should be taken to avoid anything approaching whole body irradiation by use of cones, collimators, diaphragms, lead rubber screening, etc.

4) There need be little hesitation in performing routine x-ray studies of skull, chest, upper spine and extremities other than hips since gonads can be screened adequately during such examinations. Chest examinations involve the least radiation of any of the more frequently performed examinations.

5) In the event of suspicion of injury or serious disease, it will frequently be advisable to disregard any theoretical hazards of genetic damage by using measures deemed necessary to make a proper diagnosis and to institute treatment. **In any case the medical judgment of the referring physician and radiologist as to what is necessary must prevail.** (See "Medical Dose," Table I.)

D. Discussion of approximate dosage to gonads and body from various unshielded and shielded x-ray examinations. (Table II.)

III. Protection to Personnel. Discuss with students the reasons for the following protective measures:

A. Built-in shielding. (Demonstrate Handbook 60, National Bureau of Standards; X-ray Protection, as source for descriptions of all required and recommended protective shields, devices and measures.)

1. Proper shielding of control booths, walls, floors and ceilings.
2. Importance of lead or other metal shields for fluoroscopic or other installations which would require that personnel be otherwise exposed to radiation.

B. Devices to reduce radiation to personnel.

1. Diaphragms, cones and collimators; magnetic and other cassette immobilizing devices; long handled "shovel" to hold cassettes; mobile lead screens; long cords on mobile unit timers, etc.
2. Lead rubber aprons and gloves.
3. Safety factor of distance from radiation sources (inverse square law).
4. Dangers of holding patients.
5. Importance of remaining behind shielding while making exposures.

TABLE II. APPROXIMATE DOSAGE TO GONADS IN X-RAY EXAMINATIONS WITH LEAD RUBBER SHIELDING APPLIED

(Based on averages derived from reported studies and from measurements made in Department of Radiology, Mary Fletcher Hospital, Burlington, Vt.)[4]

Part	Number of Exposures	Adult Male rems	Adult Female rems	3-year-old Child rems
Chest:				
Conventional p.a. & lat.	2	0.00016	0.0008	0.001-0.010
Photofluorography p.a. & lat.	2	0.0008	0.0400	—
Lumbosacral spine a.p. & lat.	2	0.100	0.500	0.300
Hip, a.p. & lat.	2	2.530	0.525	0.100-0.200
IV Urography	6	0.100	1.000	—
	4	0.080	0.800	0.400
Cystography	4	2.000	2.300	—
Salpingography	3	—	0.450	—
Barium enema (2 minutes fluoroscopy) 5 spots; 4 large radiographs		2.000	2.500	—
2 spots; 2 large radiographs		1.00	1.500	0.300
Upper G.I. Series (4 minutes fluoroscopy) 5 spots; 4 large radiographs		0.200	0.400	0.200
Gall Bladder Series	5	0.005	2.020	—

		Foetal Gonads rems	Maternal Gonads rems
Pelvimetry (Suggested method)	2		
Cephalic presentation		0.010	0.050-0.500
Breech presentation		0.800-2.000	0.050-0.500
Placentography	2	0.500-2.000	0.500-2.000

Examinations of the skull, cervical and thoracic spine and extremities other than hips involve such minute doses to gonads that they may be considered as negligible (0-0.010 rem)—less than is permitted as a daily dose for staff personnel.

6. Description of positions and actions of technicians during fluoroscopic examinations in order to give maximum protection.
7. Protection of technicians during use of mobile equipment, i.e., distance, long timer cord, lead apron, etc.
8. Personnel monitoring.
   a. Film badges.
   b. Pocket chambers or dosimeters.
   c. Medical control.

IV. Protection of Patient. Discuss with students the reasons for the following protective measures:

A. Shielding.
   1. General shielding.
   2. Testing of equipment for stray radiation and ray-proofing if required.
   3. Gonadal shields.
   4. Field aperture control.
      a. Diaphragms, cones and cylinders.
      b. Collimators; advantages when entire film is exposed.
      c. Importance of collimation or sharp coning of infants, extremities, skulls, chest, etc., so that total body radiation will not result.

B. Devices and techniques to reduce radiation exposure.
   1. Filtration.
   2. Fast screens and film.
   3. Adequate target-skin distance in fluoroscopy and radiography.
   4. High kilovoltage techniques.
   5. In fluoroscopy—use of low milliamperage; integrating timers.
   6. Careful attention to exposure factors and positioning to minimize re-takes.
   7. Good darkroom facilities and technique to prevent spoilage of films and consequent re-takes.
   8. In photoroentgenography, use of fast lens equipment (mirror optics, etc.).
   9. In image intensification techniques—care to use minimum milliamperage required; shutter down primary beam so that only the area to be intensified will be irradiated.

V. Examinations Requiring Special Protective Measures — See appropriate headings under Chapter on "Specialized Techniques" for more complete descriptions:

A. For patients.
   1. Pelvimetry and placentography.
   2. Urography.
   3. Pediatric radiography.
   4. Dental radiography.
   5. Photofluorography.
   6. Angiocardiography, aortography, etc.
   7. Laminography, etc.
   8. Pelvis, hips, lumbosacral spine, thighs, lower abdomen.

B. For personnel.
   1. Fluoroscopy.
   2. Cystography and retrograde urography.
   3. Angiography, etc.

4. Myelography.
5. Cinefluorography.
6. Pediatric radiography.

VI. Electrical Hazards:

A. Protection from electrical shock.
   1. Cause.
   2. How to avoid shock.
   3. Treatment.

B. Grounding.
   1. Purpose.
   2. Methods.
      a. Permanent.
      b. Temporary.
         1) Three-wire cord.
         2) Two-wire cord.
         3) Alligator clip.

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3. **The Biological Effects of Atomic Radiation:** Summary reports from a study by the Academy, 108 pp. National Academy of Sciences, Washington, D. C., National Research Council, 1956.

4. **The Rational Use of X-ray in Medicine and Dentistry with Particular Regard to Protective Measures;** A. B. Soule, M.D., Hans Heilbronn, M.D. and Ralph Bannister, R.T., THE X-RAY TECHNICIAN, 30, 244-259, January 1959. Published by The American Society of X-Ray Technicians, 16 Fourteenth Street, Fond du Lac, Wisconsin.

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7. **Radiation Dosage to Female Gonads During Diagnostic Roentgenographic Procedures;** George Cooper, Jr., M.D., Kenneth Williams, M.D., J.A.M.A., 170, 766-769, June 13, 1959.

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Chapter XVII

SPECIAL RADIOGRAPHIC PROCEDURES

OBJECTIVES:

To acquaint the student with the specialized and highly technical procedures in radiography, the equipment and opaque media used, and the general indications for each examination.

NOTE: It is suggested that selected radiographs supplement an anatomical review of the systems to be examined, prior to a consideration of radiographic procedures and techniques. A correlation of radiographic anatomy with student's general knowledge of anatomy and physiology should contribute to the intelligence with which these procedures are approached.

METHOD OF TEACHING: Lecture, demonstration, discussion, radiographs and other visual aids.

THEORY CLOCK HOURS: Twenty hours.

TIME: Second year. First semester.

INSTRUCTOR: Qualified technician, and radiologist.

I. Special Radiographic Equipment, its Function and Maintenance:

A. Body section equipment.
B. Kymographic equipment.
C. Image intensifier.
D. Rapid cassette changer.
E. Roll film cassettes.
F. Seriographic apparatus.
G. Cinefluorographic equipment.
H. Phototiming equipment.
I. Photofluorographic equipment.

II. Specific Procedures:

A. Pneumoencephalography and ventriculography.
1. Reviews of the anatomy of the ventricles of the brain and subarachnoid spaces. (radiographic anatomy).
2. Purpose of the procedures; general indications for each, contraindications in general terms so that the student will understand some of the general problems involved.
3. Discussion of contrast media employed.
4. Methods of injection of the media.
   a. Pneumoencephalography.
   b. Ventriculography (surgical procedure).
5. Equipment needed to perform each in the radiology department.
6. Duties of the technician during injection.

7. Methods of taking radiographs.
    a. With head unit.
    b. Without head unit.
8. Technique and positioning of the patient.
9. Care of the patient after procedure as far as technician is concerned.

B. Cerebral angiography.
1. Review of the circulatory system of the head. (radiographic anatomy)
2. Purpose of the procedure.
3. Methods of injection.
    a. Percutaneous.
    b. Open.
4. Media used.
5. Methods of seriography.
    a. Rapid cassette changer.
    b. Roll film seriograph.
    c. Cassette tunnels.
    d. One film method.
6. Technique and positioning.

C. Myelography and discography.
1. Review of the anatomy of the spinal canal (radiographic anatomy).
2. Purpose of the procedures.
3. Equipment needed.
4. Necessity of aseptic technique.
5. Preparation of the lumbar area for injection.
6. Media used.
7. Spinal fluid specimens to "lab" for examination.
8. "Spot" radiography during fluoroscopy by radiologist.
9. Supplementary radiographs.
10. Removal of contrast media.
11. Care of patient after procedure.

D. Bronchography.
1. Review of anatomy of the respiratory system (radiographic anatomy).
2. Purpose and general indication.
3. Preliminary preparation of the patient.
4. Opaque media used.
5. Equipment and instruments needed.
6. Anesthesia used.
7. Draping of the patient.
8. Technique of injection.
    a. Position of patient.
    b. Methods.
        1) Bronchoscopic method.

2) Tracheal catheterization method.
3) Aspiration method.
4) Nasal tube method.
5) Supra- or trans-glottic method.
6) Cricothyroid method.

9. Technique and positioning for radiography.
10. Instructions to patient and nursing division after examination.

E. Photofluorography and cinefluorography.

1. Principle of photofluorography.
2. Equipment.
   a. Photofluorographic units.
   b. Viewing apparatus.
3. Principle of cinefluorography.
4. Equipment.
   a. With image intensification apparatus.
   b. Accessories for viewing, processing film, etc.

F. Kymography.

1. Principle of roentgen kymography.
2. Multiple slit method.
3. Viewing apparatus.

G. Cardioangiography.

1. Review of the anatomy of the great vessels and chambers of the heart.
2. Purpose of the procedure.
3. Methods of injection.
   a. Cephalic or basilic vein (antecubital)
   b. Jugular vein.
   c. Other vessels.
   d. Cardiac catheterization.
4. Methods of taking radiographs.
   a. Automatic roll film seriograph.
   b. Rapid cassette changer.
   c. Cinefluorography.
   d. Biplane radiography.
5. Technique and positioning.

H. Aortography.

1. Review of anatomy.
2. Purpose of the procedure.
3. Preparation of the patient.
   a. Before the examination.
   b. At the time of the examination.
4. Equipment needed.
5. Media employed.
6. Positioning and technique.
7. Nephrograms.

I. Arteriography, venography (phlebography), vasography.
    1. Purpose of the procedures.
    2. Method of injection.
        a. Arteries.
        b. Veins.
    3. Equipment needed.
        a. For superficial arteries and veins.
        b. Surgical procedure for deeper vessels.
    4. Timing and sequence of exposures.
        a. For arteries.
        b. For veins.
    5. Media used.
    6. Positioning and technique.

J. Uterosalpingography (hysterosalpingography).
    1. Review of anatomy.
    2. Purpose of the procedure.
    3. Preparation of the patient.
    4. Equipment necessary.
    5. Opaque media used.
    6. Positioning and technique.

K. Pelvimetry.
    1. Review of anatomy.
    2. Purpose of the procedure.
    3. Methods.
        a. Thoms method.
        b. Colchner—Sussman method.
        c. Other methods.
    4. Use of compensating filter.
    5. Shielding of patient and foetus.

L. Placentography.
    1. Purpose of the procedure.
    2. Technique.
        a. Instillation of opaque media into bladder.
    3. Compensating filters.
        a. Aluminum wedge.
        b. Barium plastic.
        c. Black paper shield on half of either front or back screen.
    4. Radiation protection of patient and foetus.

M. Amniography.
    1. Purpose of the procedure.
    2. Method of procedure.
    3. Positions and technique.

N. Hepatosplenography.
    1. Review of anatomy (radiographic anatomy).
    2. Definition and purpose of procedure.
    3. Media used.

4. Method of injection, and dosage.
5. Timing, positioning and technique.

O. Retroperitoneal pneumography.
1. Review of anatomy (radiographic anatomy).
2. Purpose of the procedure.
3. Preparation of the patient.
a. Catharsis, etc.
b. Medication.
4. Aseptic precautions.
5. Injection of gas.
6. Positioning and technique.
a. Anteroposterior; posteroanterior.
b. Lateral.
c. Other.

P. Foreign body localization.
1. Purpose of the examination.
2. Fixed angle method.
3. Parallax method.
4. Foreign body in the eye.
a. Scout radiographs.
b. Lateral bone-free dental radiograph of anterior chamber.
c. Localization.
1) Comberg contact lens method.
2) Sweet's method.

Q. Sialography.
1. Review of anatomy of salivary glands and ducts.
2. Purpose of the procedure.
3. Equipment needed.
4. Opaque media employed.
5. Positions and technique.

R. Sinus tract injection.
1. Injection of external sinus tracts.
2. Paranasal sinuses.
3. Media used.

S. Body section radiography (include tomography, laminography, stratography, planigraphy, etc.).
1. Principle of body section radiography.
2. Its value and application.
3. Types of equipment.
4. Factors effecting thickness of section.
5. Simultaneous multi-section radiography.
6. Procedure and technique.

T. Scanography.
1. Purpose of the procedure.
2. Method of procedure.
a. Slit—scanography.

b. Spot—scanography.
c. Bell-Thompson ruler method.

U. Arthrography.
1. Purpose of the procedure.
2. Equipment needed.
3. Tension technique for the knee joint.
4. Positioning and technique.

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3. **Positioning in Radiography;** K. C. Clark, Published by Grune and Stratton, New York, N. Y.
4. **Body Section Radiography;** General Electric Company, Milwaukee, Wisconsin.
5. **Formulating X-Ray Technics;** John B. Cahoon, R.T., Published by Duke University Press, Durham, North Carolina.
6. **Contrast Media;** Published in The X-Ray Technician, March 1959.
7. **Special Radiographic Techniques;** Ralph Bannister, R.T., Published by The American Society of X-Ray Technicians, Refresher Course Booklet.
8. **A Review of Special and Troublesome Procedures;** Nicholas Barraco, R.T., The American Society of X-Ray Technicians, Refresher Course Booklet.
9. Material furnished by the commercial companies pertaining to their specialized equipment may also be used as source material.

Chapter XVIII

TOPOGRAPHIC ANATOMY

OBJECTIVES:

To review anatomy from the standpoint of topographic anatomy and the relationship of organs to each other. Instead of presenting the material by systems, the material should be presented according to regions of the body, the stress being upon the location of each organ using surface landmarks and the relation of the organ to other organs within the same anatomic region.

TEXT BOOK: Surface and Radiological Anatomy; Appleton, Hamilton, Simon; Williams & Wilkins Co., Baltimore, Md.

TEACHING AIDS: Skeleton, manikin, and a library of normal radiographs of the various regions studied.

THEORY CLOCK HOURS: Twelve hours.

TIME: First semester, second year.

INSTRUCTOR: M.D. or other qualified personnel.

I. Upper Extremity:

A. Topographic location of bones and major osseous landmarks.
B. Topographic location of joints.
C. Topographic location of major muscles and function of major muscle groups.

II. Lower Extremity:

A. Topographic location of bones and major osseous landmarks.
B. Topographic location of joints.
C. Topographic location of major muscles and function of major muscle groups.

III. Head:

A. Topographic location of bones of skull and face.
B. Topographic location of paranasal sinuses and mastoids.
C. Topographic location of various parts of brain with review of function.

IV. Neck:

A. Topographic location of cervical spine.
B. Topographic location of pharynx.
C. Topographic location of larynx, trachea, and esophagus.

V. Chest:

A. Topographic location of osseous structures, lungs and heart, general relationship of mediastinal structures.

VI. Abdomen and Pelvis:

A. Topographic location of digestive organs including stomach, small intestine, colon, liver and pancreas.
B. Location of spleen, kidneys, ureters, bladder.
C. Location of vascular supply to these structures.
D. Location of reproductive organs, relationship of each organ to surrounding viscera.

VII. Observation at Autopsy.

REFERENCES

1. **Normal Radiograaphic Anatomy;** I. Meschan, M.D., W. B. Saunders Company, Philadelphia.
2. **A Handbook of Anatomy and Physiology for X-Ray Technicians;** M. Mallett, M.D., The American Society of X-Ray Technicians.

Chapter XIX

RADIATION THERAPY

OBJECTIVES:

This course is designed to meet the basic minimal requirements for training of technicians in radiation therapy. It is slanted toward the student whose training is primarily in the field of diagnostic x-ray technology but whose subsequent employment may include duties in radiation therapy. The lectures are supplemented by at least one month of practical experience in the therapy department. It is recommended that experience be provided as well in the use of radium and radioactive isotopes with demonstration of the more commonly employed applicators and with emphasis placed upon the storage and handling of radioactive materials and the protective measures which must be taken in their use.

Some radiologists may find it desirable to expand this course so as to provide their students with greater knowledge and experience in mathematics, work with isotopes, etc. If so, it is suggested that they make use of the chapters on these topics as listed under "Elective Subjects."

METHOD OF TEACHING: Lecture, demonstration, discussion.

THEORY CLOCK HOURS: Ten hours.

TIME: Second year, second semester.

INSTRUCTOR: Radiologist and other qualified instructors.

I. Introduction:

Remarks about the role of radiation therapy in the treatment of disease, its relation to surgery and other specialties, etc. A brief discussion of the historical background,—damage to early workers, calling attention to the possible use of x-ray and radium in therapy of cancer. As years went by, the development first of high voltage apparatus and later of supervoltage machines; of calibrating equipment of greater and greater accuracy; and increasing knowledge of radiobiology widening the horizon.

II. Review of Physical Principles:

A. Nature of matter.

1. Atom: smallest unit of an element; consists of a nucleus and one or more electrons.
2. Nucleus: dense mass of particles (neutrons and protons) at center of atom; held firmly together by "nuclear glue." When the atom is "split," the particles come apart with great reluctance.
3. Electrons: negatively charged particles of light weight which move in orbits around the nucleus.

B. Nature of radiation.
   1. X-rays: electromagnetic energy; comes in bundles called photons; usually produced by x-ray machine; wave length depends on KV; the higher the KV, the shorter the wave length and the greater the penetration.
   2. Gamma rays: like x-rays except produced by disintegration of radioactive atoms.
   3. Beta particles: free electrons in motion; usually produced by disintegration of radioactive atoms; penetration depends on energy, but is much less than that of x- or gamma rays of similar energy.
   4. Alpha particles: nuclei of helium atoms in motion; usually produced by disintegration of radioactive atoms; non-penetrating, may be stopped by a piece of paper.

C. Radiation absorption in tissue.
   1. Ionization: removal of electrons from atoms; causes transfer of energy from radiation to tissue; essentially harmful to tissue.

D. Measurements.
   1. Units.
      a. Roentgen (r): a measure of the ability of the radiation to produce ionization; applies only to x- and gamma rays; usually measured in air.
      b. Rad: a measure of the energy absorbed in tissue; 1 rad = 100 ergs/gram; usually calculated from measurements in roentgens.
   2. Instruments.
      a. Condenser r-meter: clinical standard; measures in roentgens; useful for measuring output of equipment operating at voltages up to 2,000,000.
      b. Ionization survey meter: example: "Cutie Pie"; Sensitive to x- and gamma rays; some models sensitive also to beta and alpha particles; used to detect stray radiation, locate lost radium, etc.
      c. Personal dosimeters.
         1) Ion chambers: carried like a fountain pen; charged and read in master instrument.
         2) Self-reading ion chambers; Contain quartz fiber electroscope for reading; need only to be charged on master instrument.
         3) Film badges: special dental size film in holders suitable for attaching to clothing.
      d. Geiger counter: used for detecting and measuring minute quantities of radiation or radioisotopes; e.g., I^{131} in thyroid gland or in the urine.
      e. Scintillation counter: used for same purposes as a Geiger counter, but works on a different principle; more sensitive to x- and gamma rays.

III. Effects of Radiation on Body Tissues:

A. Historical: early workers received serious damages to skin and many later died from carcinoma or leukemia; they defined dosages in terms of "skin units," "threshold erythema dose," etc.

B. Theories of causation: many theories; the most widely held are:

1. Target or point theory: photon strikes sensitive spot in cell, producing ionization which results in injury or death of cell; if a germ cell is injured, may result in mutations in offspring.
2. Poison theory: ionizing radiation may alter molecular structure of cell fluid producing new poisonous compounds which destroy cell. Poisons may enter circulation producing general toxic manifestations.
3. Osmotic tension theory: cells may swell from increased tension and thus be damaged or destroyed.

C. Latent period: varies with dose administered; quality of radiation used, size of field, whether dose is given in one sitting or over a period of time, etc.

D. Recovery: factors are somewhat similar to "C" above; allows larger total doses to be administered by spreading them over a longer time period.

E. Factors determining effects: Note: radiation is always depressant or destructive and never stimulating to bodily tissues.

1. Effective wave length; kilovoltage.
2. Target-skin distance.
3. Filtration used.
4. Size of field.
5. Inherent radiosensitivity or radioresistance of area exposed.
6. Dosage—daily, cumulated.
7. Tolerance of patient to radiation.

F. Local effects.

1. Skin and mucous membranes.
   a. Acute or sub-acute.
      1) Type and intensity of effects depends on factors listed under "E" above but resemble thermal action; from small doses, no apparent effect; from moderate doses, erythema; from larger doses, vesiculation, epidermitis or epithelitis or superficial necrosis; from very large doses, deep necrosis.
      2) Recovery depends on severity of reaction and end results include:
         a) Complete recovery.
         b) Healing with atrophy, scarring, temporary or permanent epilation; telangiectasis.

c) Delayed or no healing with ulceration and scarring (seldom seen following radiation therapy today).

b. Chronic: usually from repeated exposures over a long period of time; rarely seen today.
   1) Atrophy of skin and sweat glands.
   2) Epilation: telangiectases; impaired circulation.
   3) Chronic ulceration.
   4) Secondary malignant disease.

c. Types of skin changes expected following radiation therapy.
   1) From "blast" type of localized therapy for removal of epithelioma.
   2) Usual types of skin reactions following therapy of such conditions as pelvic carcinoma, laryngeal carcinoma, etc.
   3) Importance of referring to these changes as "radiation reactions" and **not** as "burns."

2. Bone marrow: depressing effects from large doses; how evidenced; precautionary measures, etc.
3. Gonads.
   a. Castration effects; dosages required; precautionary measures, etc.
   b. Genetic effects: (previously discussed in chapter "Radiation Protection").
4. Skeletal system: effects on growing bones; e.g., radiation over epiphyseal lines of extremity bones or of the vertebrae in treating Wilms' tumor.
5. Other special systems:
   a. Lymphoid tissue.
   b. Alimentary tract and liver.
   c. Urinary tract, especially bladder.
   d. Nervous system, especially brain, spinal cord, eyes.

G. General effects.
1. Radiation sickness: factors which contribute to it including psychological; suggestions as to how the technician may assist the radiologist in prevention and treatment.
2. Anemia: granulopenia. (see "F.2" above).
3. Effects of total body radiation, especially from atomic blast, etc.
   a. Lethal dose: 400 ± r. (Note that under controlled conditions of radiation therapy, 4,000 r or more may be given safely to a small localized field).
   b. Usual symptoms and signs: general discussion of management.

IV. Neoplasms:

A. Introduction. A general presentation,—what they are; how they grow; how they differ from normal tissue.

1. Malignant tumors.
    a. Commoner varieties (carcinomas, sarcomas, lymphomas, leukemias).
    b. Commoner locations.
    c. How they differ from benign tumors.
    d. Characteristics of growth (local invasion; metastases).
    e. Why and how they destroy life.
    f. Radiosensitivity vs. radioresistance.
    g. Aims of radiation therapy:
        1) Cure (radiation alone or with surgery or other).
        2) Palliation.
2. Benign tumors.
    a. Commoner locations and varieties.
    b. Aims of radiation therapy.
        1) Relief of symptoms and restoration of function.
        2) Cosmetic effects (e.g., hemangioma).
        3) Precancerous lesions.

V. Inflammatory (Non-Neoplastic) Lesions Treated with Radiation:

A. Description of those commonly treated.

B. Aims of therapy.

VI. Methods of Employing Radiation Therapy:

A. Equipment and techniques: it is suggested that each type of equipment be demonstrated and its particular use discussed, together with any special features which the radiologist believes the technicians should understand. This training exercise must of necessity be individualized but should include consideration of the following:

1. Low voltage x-ray therapy (Grenz rays, "Contact" therapy, superficial x-ray therapy).
2. Medium voltage therapy (140 ± kv).
3. High voltage or "deep" therapy (200—400 kv).
4. Supervoltage therapy.
5. Rotational therapy.
6. Intracavitary therapy.

B. Instruction in "setting up" the patient; methods of immobilization; checking of filters, shutters or cones, etc. It is suggested that even though these are performed by the radiologist, the technician should understand the steps taken so that he may assist properly and can be part of the "double-check" team.

C. Detailed instruction in the operation of the controls and the points to be checked in every treatment operation.

VII. Radioactive Materials (radium, radon, cobalt, strontium, etc.). Also see chapter on "Radioisotopes":

A. Types of conditions in which each is used.
B. Containers and applicators; suggested that these be demonstrated.
    1. Plaques.
    2. Needles, tubes, cells.
    3. Seeds or threads.
    4. Radium or Cobalt^{60} bomb.
    5. Isotopes in solution.
C. Problems of storage, screening and protection of each.
D. Types of applications used.
    1. Surface (contact and short distance applications).
    2. Intracavitary; e.g., intrauterine, intraoral, etc.
    3. Interstitial.
    4. In pleural or peritoneal cavities (e.g., Au^{198}).
E. Moulds and their construction.
F. Problems of handling.
    1. Loading of applicators.
    2. Transportation to and from patient.
    3. Protection during application.
    4. Protection of patient and personnel during period of therapy.
    5. Unloading of applicators after use; checking of contents; storage.
    6. Disposal of radioactive waste.

VIII. Therapy Planning:

Note: It is suggested that the average student not be required to understand many of the principles of dosage computation, plotting of isodose curves, etc. It is suggested, however, that the actual computation of dose and the procedure followed in planning a course of therapy for a patient be demonstrated by the radiologist so that the students may be made aware of the complexities involved and the necessity for utilizing the specialized knowledge of the radiologist in general medicine, anatomy, pathology (especially oncology), physics, mathematics and radiobiology. This will demonstrate to them graphically how important it is that the radiologist's orders be carried out in every detail.

IX. Protective Measures: Review those phases of radiation protection already covered in Chapter XVI—"Protection Against Electrical and Radiation Hazards" as they apply specifically to radiation therapy. These should include:

A. Built-in protection in walls, floors, ceilings and windows of therapy rooms and booths.
B. Limitations of radiation to patient by diaphragms and cones, and in some cases by added shielding of sheet lead or rubber.
C. Necessity of keeping relatives and others out of therapy room during

administration of radiation. This may require use of general anesthetics or sedatives to children or non-cooperative patients.

D. Protection during handling of radioactive materials. (see "VII F" above).

X. Nursing Procedures—Review those phases previously covered in Chapter XIII—"Nursing Procedures in Radiology," especially as they apply to therapy:

A. Proper gowning and draping of patients.

B. Placement of patients for special examinations.

C. Antiseptic and aseptic techniques; cleansing of instruments; disposal of soiled dressings.

XI. Record Keeping:

A. Medical and legal responsibilities of radiologist and technician; importance of complete and accurate records.

B. Specific instructions as to what, when and how to record data.

C. Records other than individual case record.

1. Daily log, monthly or other reports.
2. In some departments, billing, accounting, insurance, etc.
3. Scheduling of future visits.
4. Notification of the radiologist of missed appointments and follow-up if so instructed.
5. Record of adjustments, repairs and other maintenance on all machines.
6. Records of r-output of all machines at various settings.

XII. Professional Relationships:

A. Physician, technician, patient, family, social service agency.

B. Professional ethics. Specifically, technicians should be instructed to divulge to **no one** other than the therapist what they may see, hear or learn regarding any aspect of the patient's case.

C. The technician should promptly inform the radiologist of any change noted in the condition of the patient or any complaints or symptoms which the patient may mention. (Patients will sometimes confide in a technician before speaking to the radiologist).

XIII. Psychological Needs of the Patient:

A. Those with uncertain prognosis.

B. Those with poor prognosis.

C. Those in late or terminal stages.

D. Attitudes of technician: Emphasis on the importance of being quietly compassionate and sensitive to the physical and mental well-being of the patient and relatives; pleasant and cheerful when possible, but not over-demonstrative or "Pollyanna-ish." Technicians should not lie to

patients but should refuse to discuss prognosis or any other aspect of the patient's medical condition.

XIV. Other Responsibilities of the Technician:

A. The therapy technician should know all machines thoroughly and not be allowed to operate the controls alone until he is fully trained and experienced to do so.

B. Before each treatment he should study the plan of therapy and should select the proper cone and check the presence of the proper filter; he may be taught to place the patient in approximately the position which will be used. **All of these will then be checked by the radiologist who will make the final placement,** but the double check by technician and radiologist reduces the possibility of personal error.

C. During administration of the treatment, the technician should keep both the controls and the patient under constant scrutiny; never leave the controls unattended. He should recognize malfunction of equipment immediately and turn off the machine and call the radiologist if such occurs or if the patient shows signs or symptoms which are alarming or if the patient changes position.

D. In some departments technicians may be trained to assist the radiologist, the radiological physicist or the resident in making calibration measurements, etc.

REFERENCES

1. **Physical Foundations of Radiology;** Glasser, Quimby, Taylor, Weatherwax; Published by Hoeber, New York.
2. **Radiotherapy;** J. Walter and H. Miller, Published by The Blackiston Co., Philadelphia, Pa.
3. **Therapeutic Radiology;** Holmes and Schultz, Published by Lea and Febiger, Philadelphia, Pa.

Chapter XX

INTRAORAL RADIOGRAPHY

OBJECTIVES:

To provide the student with an understanding of the anatomy and contours of the teeth and mouth and of the geometry of image formation of this area. To familiarize him with the essential equipment and accessories used in dental radiography and to point out the necessity of exact positioning of the central ray and the film in order to produce high quality radiographs.

METHOD OF TEACHING: Lectures and demonstrations.

THEORY CLOCK HOURS: Eight hours.

TIME: Second year, second semester.

INSTRUCTOR: Chief technician or other qualified instructor.

I. Anatomy and Landmarks:

- A. Review of anatomy of mandible and maxilla.
- B. Deciduous and permanent teeth.
  - 1. Year of eruption.
  - 2. Number of each.
- C. Surface landmarks for identifying underlying structures.

II. Types of Radiographic Examinations and their Purpose:

- A. Periapical.
- B. Interproximal.
- C. Occlusal.

III. Preliminary Consideration:

- A. Explanation of the control panel of the dental unit.
- B. Circuit breaker.
- C. Timer.
- D. Types and sizes of dental films.
- E. Short cone and long cone techniques.
- F. Position of patient in dental chair.
- G. Position of patient on general radiographic table.
- H. Comfort of patient.
- I. Immobilization of head.
- J. Importance of cleanliness.

IV. Geometry of Image Formation:

- A. Method of determining the vertical angle of central ray.
  - 1. With average vault.

2. With high vault.
3. With low vault.
4. Edentulous patients.

B. Correct horizontal projection of central ray.

V. Periapical Techniques:

A. Head position.
B. Film adaption.
C. Film placement.
D. Film retention (Digital method).
E. Film retention (Bite-block method).
F. Vertical angle of central ray.
G. Horizontal angle of central ray.
H. Landmarks.
I. Exposure.

VI. Interproximal Techniques:

A. Purpose.
B. Advantage.
C. The incisor-cuspid region.
    1. Head position.
    2. Placement of packet.
    3. Retention of packet.
    4. Projection of central ray.
    5. Technical factors.
D. The bicuspid-molar region.
    1. Head position.
    2. Placement of packet.
    3. Retention of packet.
    4. Projection of central ray.
    5. Technical factors.

VII. Occlusal Radiography:

A. Purpose.
    1. Cross-sectional views of dental anatomy.
    2. To demonstrate fracture.
    3. For salivary calculi.
    4. For pathology.
B. Positioning.
    1. Position of the head.
    2. Placement and retention of packet.
    3. Projection of central ray.
    4. Technical factors.
        a. Maxillary incisor region.
        b. Maxillary cuspid-molar region.

c. Entire maxillary denture.
d. Mandibular incisor region.
e. Mandibular cuspid-molar region.
f. Entire mandibular denture.
g. Projection for salivary calculi.

VIII. Mounting of Dental Radiographs:

A. Types of mounts.
B. Identification of teeth.
   1. Relation of embossed dot to tube.

IX. Protection:

A. Equipment.
   1. Modern, shock-proof, ray-proof equipment.
   2. New high kilovoltage equipment offers techniques with smaller doses of radiation to patient.
   3. Importance of long cone versus short cone technique.
   4. Proper diaphragming of cone to limit radiation to no more than a circle 3" diameter at the tip of the cone.
   5. Adequate filtration—2 mm Al.
   6. Ultra-speed dental films 6 times faster than regular films.
   7. Lead rubber apron or bib for patient.
   8. Lead booth or screen for operator.

B. Operation.
   1. Use of as high KV technique as machine will allow; with consequent lower MAS.
   2. Careful attention to positioning of tube and film to minimize retakes.
   3. Control over the number and frequency of exposures (the responsibility of the dentist, referring physician or radiologist and not primarily that of the technician).

REFERENCES

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2. **X-Ray Technique;** Ritter Company, Inc., Rochester, N. Y.
3. **Radiation Dose Reduction in Dental Radiography;** Lewis E. Etter, M.D., S. S. Sidhu, Ph.D. and L. C. Cross, R.T., American Journal Roent., Rad. Ther., and Nucl. Med. 80, 926-932, December 1958.

Chapter XXI

A SURVEY OF MEDICAL AND SURGICAL DISEASES

OBJECTIVES:

To acquaint the student with certain changes that occur in disease and injury and their application to x-ray technology. An understanding of these should enable the technician to handle seriously ill or injured patients more intelligently, to produce more informative radiographs and to obtain greater satisfaction from his work. This is not intended as a detailed course in pathology. It is suggested that the instructor emphasize the features of the various conditions which should be known by the technician in performance of the indicated x-ray examinations.

METHOD OF TEACHING: Lecture and illustrations.

THEORY CLOCK HOURS: Fifteen hours.

TIME: Second year, second semester.

INSTRUCTOR: Radiologist, resident in radiology or other physician.

I. Introduction:

A. Definitions: pathology, etiology, pathological anatomy, pathological physiology, subjective symptoms, objective signs, diagnosis, prognosis.

B. Nature and cause of diseases.

1. Congenital; hereditary.
2. Trauma; mechanical, thermal, from poisons, etc.
3. Bacterial or viral; inflammation; infection.
4. Disturbance in circulation: hyperemia, ischemia, hemorrhage, thrombosis, embolism, edema, surgical shock.
5. Degenerative diseases: general brief discussion with examples such as arteriosclerosis, senile osteoporosis, Paget's disease, pulmonary emphysema, etc. Consideration will be given to others below under specific systems.
6. Neoplastic diseases: general brief discussion of benign and malignant tumors.

II. Lesions Affecting Organs or Systems (with stress on x-ray techniques):

A. Cardiovascular System: especially rheumatic heart disease, congenital heart disease, hypertensive disease. Commoner abnormalities of arteries and veins as shown by aortography, arteriography, phlebography.

B. Respiratory tract: especially common cold, sinusitis, pneumonia, bronchiectasis, tuberculosis (including problem of communicability), atelectasis, emphysema, foreign bodies in air passages, silicosis, tumors, pleurisy, empyema, pneumothorax.

C. Digestive tract: especially foreign bodies, peptic ulcer, carcinomas and other neoplasma of stomach and bowel, diverticulitis, intestinal obstruction, appendicitis and peritonitis, ulcerative colitis, ascites.

D. Liver and biliary system: especially hepatitis, cholecystitis, cholelithiasis, neoplasms.

E. Urinary tract: especially nephritis, urinary calculi, tuberculosis, neoplasm of kidney, bladder and prostate gland, obstructive lesions.

F. Female reproductive tract: Leiomyomata (fibroid tumors), uterine and ovarian carcinoma; dermoid and other cysts of ovaries, extra-uterine pregnancy, sterility, especially from tubal obstruction, tumors of breast.

G. Ductless glands: especially abnormalities of thyroid, parathyroid, adrenal and pituitary glands.

H. Blood and lymphatic glands: especially anemia, hemophilia, leukemia, tuberculous adenitis, lymphoma, Hodgkins' disease.

I. Central nervous system: especially cerebral accidents, tumors, aneurysms, meningitis, injury to brain and spinal cord.

J. Skeletal system:
   1. Common anomalies.
   2. Fractures and dislocations.
   3. Effects of aging, disuse, hyperemia, etc.
   4. Commoner diseases affecting bones and joints: especially nutritional deficiency states (rickets, scurvy), osteochondritis, arthritis, infections, metabolic diseases, neoplasms (primary and secondary).

REFERENCES

1. **An Introduction to Medical Science;** William Boyd; Published by Lea & Febiger, Philadelphia, Pa.
2. **Introduction to Medical Science;** Muller & Dawes, Published by W. B. Saunders Company, Philadelphia, Pa.
3. **Patient Care and Special Procedures in X-ray Technology;** Carol Hocking Vennes, R.N., B.S., and John C. Watson, R.T., Published by C. V. Mosby Company, St. Louis, Missouri.
4. **Nursing in Clinical Medicine;** Jensen & Jensen, Published by MacMillan Company, New York, N. Y.
5. **Fundamentals of Nursing;** Fuerst & Wolf, Published by J. B. Lippincott Company, Philadelphia, Pa.

Chapter XXII

DEPARTMENTAL ADMINISTRATION

OBJECTIVES:

To acquaint the student with the organization, function, supervision, and financial arrangements relative to departments of radiology.

To present correct departmental, intra- and inter-departmental relationships, such as those pertaining to attitudes and policies relative to personnel management.

NOTE: Portions of this subject (notably sections VI and VII dealing with the general office routine and departmental records) may be taught at the discretion of the school during the first semester of the first year.

METHOD OF TEACHING: Lecture, discussion.

THEORY CLOCK HOURS: Ten hours.

TIME: Second year, second semester.

INSTRUCTOR: Chief technician, radiologist, office supervisor.

The Department of Radiology and the Hospital

I. Organizational Factors:

A. Management and operation.
   1. Corporate organization.
      a. Definition.
      b. Board of control.
   2. Types of organization.
      a. Operated for profit (privately owned).
      b. Operated for non-profit (community controlled).
      c. Charity organizations.
      d. Governmental.
   3. Governing body.
      a. Board of trustees.
      b. Medical boards.
      c. Administrators.
      d. Departmental directors.

II. Administrative Factors:

A. Location of Radiology Department.
   1. Proximity to surgical division.
   2. Proximity to emergency ward.
   3. In pediatrics separated from other divisions.

B. Planning.
    1. General layout.
    2. Ventilation (air conditioning).
    3. Protective barriers,—walls, floors, ceilings.
    4. According to type of equipment to be used (i.e., overhead tube stands, etc.).
    5. Room sizes.

C. Personnel.
    1. Medical staff.
        a. Director-diplomate of board of radiology (or equivalent).
        b. Other radiologists in department.
        c. Residents in radiology.
    2. Technical staff.
        a. Administrative or chief technician—supervisor.
        b. Senior technicians.
        c. Staff technicians.
        d. Radiotherapy and isotope technicians (optional).
    3. Student technicians.
    4. Secretarial and clerical staff.
    5. Nursing aides.
    6. Others.

Departmental Relationships

I. Relationships with Other Departments:

A. Consulting medical staff.
B. House staff.
C. Nursing service.
D. Social service.
E. Service departments.
    1. Admitting office.
    2. Accounting office.
    3. Medical record library.
    4. Emergency service.
F. Maintenance division.
    1. Engineering department.
    2. Housekeeping department.
        a. Maid service.
        b. Janitor service.
    3. Laundry facilities.

II. Relationships Within the Radiology Department:

A. Director of the department and his staff.
    1. Radiologist.
    2. Associate or assistant radiologists.
    3. Residents in radiology.

4. Medical students in radiology.

B. Administrative technician—supervisor and staff.
   1. Supervisor or chief technician.
   2. Senior technicians.
   3. Staff technicians.
   4. Radiotherapy technician (optional).
   5. Office and secretarial staff.
   6. Nursing and technical aides.
   7. Student technologists.

C. Relationship of department to school of x-ray technology.
   1. Director of school—radiologist.
   2. Educational director. (May be combined with duties of departmental administrator or supervisor.)
   3. Faculty. (Includes those listed in "C" No. 1 and No. 2 above and the necessary number of classroom and clinical instructors.)

D. Relationships with the school of nursing.
   1. Contribution of nursing school to department of radiology.
   2. Contribution of department of radiology to school of nursing.

Financial and Legal Considerations

I. Financial Control:

A. Budget.
B. Non-budget.

II. Recompense for Services Rendered:

A. Salaries of non-medical personnel.
B. Fringe benefits.
   1. Insurance plans.
   2. Retirement plans.
   3. Vacation policies.
   4. Sick leave policies.
   5. Opportunities for professional growth (scientific meetings).
   6. Health insurance plans.

III. Service Charges to Patient:

A. Charge per examination.
B. Rendering of bills.
C. Accounts kept.

IV. Estimating Cost of Department:

A. Monetary recompense to medical, technical and clerical staff.
B. Monetary recompense to auxiliary staff.
   1. Maid service.
   2. Janitor service.

3. Maintenance service.
4. Laundry service.

C. Floor space.

D. Utilities.
1. Heat.
2. Light.
3. Electricity.
4. Water.

E. Supplies.
1. Film.
2. Chemicals.
3. Stationery—postage.
4. Linens.
5. Opaque media.
6. Surgical.
7. Pharmaceuticals.
8. Miscellaneous.

F. Replacements.
1. Equipment.
a. Tubes.
b. Cables.
c. Miscellaneous.
2. Accessories.
a. Cassettes.
b. Grids.
c. Screens.
d. Other.

G. Depreciation of equipment.

H. Insurance.
1. Accident—rate higher for electrical hazard occupation.
2. Overall for hospital—should be pro-rated for department.
a. General.
b. Wind and storm.
c. Fire.

V. Legal Considerations:

A. Every case a potential court case.

B. Legal responsibility of:
1. Radiologist.
2. Technician.
3. Clerical.

C. Custody of roentgenograms.

D. Importance of adequate records—permanent filing.

E. Subpoena.

F. Accurate identification.

VI. Departmental Records:

A. X-ray register or log sheets.
B. X-ray requisition.
C. X-ray report.
D. Charge slips.
E. Monthly and annual reports.
F. Other.

VII. Filing Systems:

A. Card.
B. Statistical.
C. Pathological cross-index.
D. X-ray patient numbers.
E. Other.

VIII. Preparation of Schedules:

A. Appointment.
B. Work schedules.
C. Personnel assignment.
D. Weekend and night coverage.
E. Other.

REFERENCES

1. **The Roentgenologist in Court;** Samuel W. Donaldson, 2nd edition, Published by Charles C. Thomas, Springfield, Illinois.
2. **Selecting and Inducting New Employees;** George D. Halsey, Published by Harper Publishing, New York.
3. **Law of Hospital, Physician, and Patient;** Hayt, Emanuel, Lillian R. Hayt, August H. Groschel, Published by Hospital Textbook Co., New York.
4. **Human Factors in Management;** Schyelor D. Hoslett, Published by Harper Publishers, New York.
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8. **X-Ray Protection, Handbook 60;** U. S. Dept. of Commerce, National Bureau of Standards.
9. **Effective Communication on the Job;** M. J. Dooher, American Management Assn., N. Y.
10. **The Administrative Process;** R. H. Roy, Published by Johns Hopkins Press, Baltimore, Md.
11. **Radiologic Records;** Sister Christina Spirko, R.T., Published by Charles C. Thomas, Springfield, Illinois.

Chapter XXIII

EQUIPMENT MAINTENANCE

OBJECTIVES:

To familiarize the student with the component circuits of an x-ray unit, to permit detection and correction of simple difficulties which interfere with or prevent the proper function of the equipment or accessories; as well as fundamentals of preventive maintenance to avoid expensive breakdown.

METHOD OF TEACHING: Lecture, demonstration of equipment and methods.

THEORY CLOCK HOURS: Six hours.

TIME: Second year, second semester.

INSTRUCTOR: Chief technician, service representatives.

I. Care and Maintenance of Accessory Items.

II. Mechanical Breakdowns:

A. Causes.
B. Corrective measures.
C. Preventive measures.

III. Electrical Circuits:

A. Power supply.
B. Timer.
C. X-ray tube filament.
D. Valve tube filament.
E. High-tension.
F. Control and auxiliary.

IV. Electrical Breakdowns:

A. Power supply circuit.
B. Timer circuit.
C. X-ray tube filament circuit.
D. Valve tube filament circuit.
E. High-tension circuit.
F. Control and auxiliary circuits.
G. Causes, corrective and preventive measures of each.

V. Test Equipment and Use of:

A. AC-DC voltmeter.
B. Continuity tester.

C. Test lamps.
D. Spinning top.
E. Cycle counter.
F. Aluminum step wedge.
G. Miscellaneous tools.

REFERENCES

1. **Radiologic Trouble Shooting;** R. A. Olden, R.T., The X-Ray Technician 22:355, May, 1951.
2. **Roentgenographic Technique;** D. A. Rhinehart, Published by Lea & Febiger, Philadelphia, Pa.
3. **Military Roentgenology;** War Department, Published by Supt. of Documents, Washington 25, D. C.

Chapter XXIV

PSYCHOLOGY

(Elective)

OBJECTIVES:

It is desirable that the student have a basic knowledge of psychology. It will help him to understand himself and to develop a healthier attitude toward his co-workers and the patient on whom he practices his skills. It will also facilitate his own integration into our social structure of which he is a part.

METHOD OF TEACHING: Lecture.

THEORY CLOCK HOURS: Four hours.

TIME: Second year, first semester.

INSTRUCTOR: Physician preferably, or psychologist.

I. Introduction:

A. Definition of psychology.
B. Reason for teaching psychology to students.
C. Understanding motivation, frustration and emotion in student's behavior and in that of others.
D. Help the student to develop better study habits.

II. Learning:

A. Study habits.
B. Memorization-acquiring a scientific vocabulary.
C. Motivation of learning.
D. Effective study methods.
E. Dependence of intelligence on environment and heredity.

III. Personality:

A. Getting along well with others.
B. Personality adapts to change in environment.
C. Health conditions: nutrition, sleep and recreation.
D. Work habits.
E. Adjustment to conflict.

IV. Psychology of varying groups:

A. Child psychology.
B. Adolescent psychology.
C. Psychology of maturity.
D. Psychology of old age.

E. Psychological reactions of the sick and injured.
F. Psychological reactions of relatives of patients.

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4. **Achieving Maturity;** J. Waters, Published by McGraw-Hill Book Co., Inc., New York.
5. **The Development of Human Behavior;** Dewey, R. and W. J. Humber, Published by the MacMillan Company, N. Y.

Chapter XXV

MEDICAL USE OF RADIOISOTOPES

(Elective)

OBJECTIVES:

To acquaint the student with the necessary physics, the fundamentals of radioisotope technique and the role of the technician in their use. Training of technicians in the relatively new field of medical use of radioisotopes usually implies development of skills in laboratory as well as in radiological technology. Basic courses in chemistry, physics, mathematics and biology are desirable but not necessarily essential prerequisites for training in this field.

I. Radioisotopes:

A. Introduction.
   1. Basic physics (review); definitions.
      a. Atomic theory.
      b. Atomic number.
      c. Atomic weight.
      d. Isotopes.
      e. Isomers.
      f. Radioactivity.
   2. Types of radioactivity.
      a. Alpha particles.
      b. Beta particles.
      c. Gamma radiation.
   3. Characteristics of radioisotopes.
      a. Decay.
      b. Half life.
      c. Average life.
      d. Decay constant.
   4. Methods of production.
      a. Natural.
      b. Artificial.
   5. Enumeration of useful radioactive elements.
      a. Diagnostic.
      b. Therapeutic.
   6. Statistical problems of radiation measurement.
   7. Mathematics review: calculators and slide rule.

B. Terminology and units.
   1. Curie.
      a. Millicurie.
      b. Microcurie.
   2. Rad.
   3. Rem.

4. Relative biological effectiveness.
5. Roentgen.
    a. Milliroentgen.
    b. Mr/hr.
6. Maximum permissible dose.
    a. Occupational.
    b. For general population.
7. Fission.
8. Fusion.
9. Linear energy transfer (specific ionization).
10. Counts/minute.

C. Instrumentation.
1. Counting equipment and detectors for diagnostic purposes.
    a. Geiger counter.
    b. Scintillation counter.
    c. Scintiscanner.
    d. Scaler.
    e. Count rate meter.
2. Survey instruments.
    a. Geiger counter survey meter.
    b. Ionization chamber survey meter.
3. Personnel monitoring equipment.
    a. Dosimeter or pocket chamber.
    b. Film badge.
4. Radiation protection equipment.
    a. Remote handling equipment.
    b. Radiochemical facilities.
    c. Shielding.
    d. Storage of radioactive material.

D. Laboratory techniques.
1. Use of volumetric glassware.
2. Use of centrifuge.
3. Sterile technique.
4. Intravenous injections.
5. Handling of blood.
    a. Drawing venous blood.
    b. Preventing coagulation.
    c. Separation of cells and plasma.
    d. Determination of hematocrit.
6. Preparation of samples for counting.
    a. Dry solid samples.
    b. Liquid samples.
7. Presentation of samples to counts.

E. Specific procedures.
1. Radioiodine.
    a. Standardization.

b. Diagnostic procedures and techniques.
    1) Uses.
        a) Thyroid diagnosis: 24 hr. and 48 hr. uptakes, uptake curves, urinary excretion and protein bound iodine conversion ratio.
        b) Blood volume.
        c) Brain tumor localization.
        d) Peripheral vascular studies.
        e) Cardiac output.
        f) Intestinal absorption.
        g) Kidney function.
        h) Additional procedures.
    2) Equipment.
    3) Administration.
    4) Measurement.
    5) Calculations.
    6) Interpretations.
c. Therapeutic.
    1) Non-malignant conditions.
        a) Calculation of dose.
        b) Use.
        c) Rationale of administration.
        d) Administration of dose.
    2) Malignant conditions.
        a) Calculation of dose.
        b) Use.
        c) Rationale of administration.
        d) Administration of dose.
        e) Special precautions: urine, etc.

2. Radiogold.
    a. Standardization.
    b. Therapeutic procedures and techniques.
        1) Uses.
        2) Equipment.
        3) Administration.
        4) Precautions.
3. Radiophosphorus.
    a. Standardization.
    b. Diagnostic applications.
        1) Tumor localization.
        2) Red cell survival.
    c. Therapeutic procedures and techniques.
        1) Lymphomas.
        2) Leukemias.

4. Radiochromium.
    a. Standardization.
    b. Uses.
        1) Blood volume.
        2) Red cell survival.
5. Radiocobalt.
    a. Standardization.
    b. Diagnostic use: Schilling test.
    c. Therapeutic uses.
6. Radiostrontium.
    a. Standardization.
    b. Treatment for superficial lesions.
7. Miscellaneous radioisotopes.
    a. Diagnostic procedures and techniques.
    b. Therapeutic procedures and techniques.

F. Decontamination and safety procedures.
1. Benches and floors.
2. Instruments.
3. Glassware, pipettes, etc.
4. Disposal.
5. Testing sealed sources for leakage.
6. Handling of accidents involving radioactive material.
7. Periodical laboratory survey.

II. Radiation Protection (See Chapter XVI):

III. Nursing Procedures Pertaining to Radioisotopes—See Chapters on Radiation Therapy and Nursing Procedures:

IV. Records and Administrative Procedures:

A. Departmental administration.
B. Coding and filing.
C. Relations with other agencies, i.e., Tumor Clinic, Social Service, etc.
D. Appointments.
E. Correspondence.
F. Procurement of radioactive materials.
1. A.E.C. rules and regulations.
2. Application forms.
3. Sources of supply.

REFERENCES

1. **Basic Foundations of Isotope Technique for Technicians;** Willard C. Smullen, M.D., Published by Charles C. Thomas, Springfield, Illinois.
2. **Clinical Use of Radioisotopes;** Theodore Fields, M.S., and Lindon Seed, M.D., Published by Year Book Publishers, Chicago, Illinois.
3. **Radioactive Isotopes in Clinical Practice;** H. Quimby, Sc.D., Sergei Feitelber, M.D., and Solomon Silver, M.D., Published by Lea & Febiger, Philadelphia, Pa.

Chapter XXVI

PHOTOGRAPHY

(Elective)

OBJECTIVES:

A knowledge of the theory and technique of photography will provide the student with background in a subject that is closely allied to radiography. The copying of radiographs, charts and text material, the making of lantern slides, and the photography of equipment, and new or unusual radiographic positions will supply the radiology department with much useful teaching material as well as provide a stimulus for the preparation of articles for publication.

The effect of light upon photographic material, and the exposing and processing of negatives and prints give the student an appreciation of the qualities of these materials which is of value not only for its own sake, but also to teach him to correctly evaluate radiographic quality.

I. Light:

A. Nature of light.
   1. Characteristics.
   2. Transmission.
   3. Absorption.
   4. Refraction.

II. Optics:

A. Lenses.
   1. Focal length.
   2. Depth of focus.
   3. Depth of field.
   4. Diaphragms and stop numbers.
   5. Image size.

III. Cameras:

A. View camera.
B. Press camera.
C. Miniature camera.
D. Lenses and shutters.
E. Range finders.

IV. Photographic Film:

A. Physical properties.
B. Grain size.
C. Film speed.
D. Contrast.
E. Color sensitivity.

F. Latitude.
G. Types: roll, sheet, pack.

V. Exposing the Photograph:

A. Composition.
B. Camera angle.
C. Camera adjustments.
    1. Swing back.
    2. Lens board.
D. Exposure.
    1. Exposure guides.
    2. Exposure meters.
    3. Filters.
        a. Factors.
    4. Flash photography.

VI. Photographic Processing:

A. Composition and purpose of solutions.
B. Types of developer.
C. Processing techniques.
D. Safelight filters.
E. Open and closed tank development.
F. Reduction and intensification.

VII. Contact Printing:

A. Contact printers.
B. Contact printing papers.
C. Printing techniques.
D. Exposure and processing.
E. Washing and finishing.
F. Drying and ferrotyping.
G. Dodging techniques.
H. Lantern slides.
I. Intermediate positives of radiographs.
J. Solarization of radiographs.

VIII. Projection Printing:

A. Projection printers.
B. Projection papers.
C. Exposure and processing.
D. Dodging and cropping.
E. Mounting of prints.
F. Lantern slides and transparencies.
G. Positive image prints and intermediates.
H. Transparencies.

IX. Copying:

A. Equipment.
B. Charts and graphs.
C. Copying radiographs.

REFERENCES

1. **Kodak Reference Handbook;** Published by Eastman Kodak Company, Rochester, N. Y.
2. **This is Photography;** T. H. Miller and Wyatt Brummett, Published by Garden City Publishing Company.
3. **Photography Principles and Practice;** C. B. Neblette, Published by D. Van Nostrand Company, Inc., New York.
4. **Camera and Lens;** Ansel Adams, Published by Morgan and Lester, New York.
5. **Fundamentals of Photographic Theory;** T. H. James, George C. Higgins, Published by Morgan and Morgan, New York.

Chapter XXVII

PRINCIPLES OF TEACHING

(Elective)

OBJECTIVES:

To acquaint the student with the principles and techniques of good teaching to enable him to assume teaching responsibilities after graduation from a school of x-ray technology.

I. Planning a Training Program:

A. Stages in the teaching process.
B. Selection of curriculum.
C. Selection of instructors.
D. Selection of classroom area.
E. Preparation of lesson plans.

II. Planning a Training Schedule:

A. Preparation of master schedule.
B. Preparation of weekly schedule.

III. Student Records and Forms:

A. Application.
B. Master record.
C. Examination records.
D. Efficiency or personal evaluation reports.
E. Schedules of work assignments.
F. Use of aptitude testing for selection.
G. Other.

IV. Types and Use of Examinations and Tests:

A. Subjective questions.
    1. Essay.
    2. Oral.
    3. Advantages and disadvantages of each.
B. Objective questions.
    1. True—false.
    2. Multiple choice.
    3. Matching.
    4. Rearrangement.
    5. Completion.
    6. Identification.
    7. Enumeration.
    8. Advantages and disadvantages of each.
C. Preparation of examinations and tests.

D. Testing techniques.
   1. Scoring.
   2. Grading.
   3. Evaluation.

V. Instructor Attributes:

A. Appearance.
B. Relations with students.
C. Skill in profession.
D. Deportment.
E. Speech, voice and vocabulary.
F. Mannerisms.

VI. Methods of Teaching:

A. Lecture.
B. Discussion.
C. Demonstration.
D. Illustration or case.
E. Individual report.
F. Advantages and limitations of each.

VII. Use of Audio-Visual Aids:

A. Blackboard.
B. Models.
C. Textbook illustration.
D. Posters and photographs.
E. Diagrams, drawings and sketches.
F. Graphs and charts.
G. Field trips.
H. Slides and filmstrips.
I. Motion picture films.
J. Advantages, disadvantages and limitations of each.

REFERENCES

1. **250 Teaching Techniques;** Estabrooke and Karsh, Published by Bruce Publishing Company, Milwaukee, Wisconsin.
2. **Tested Training Techniques;** Maas and Ewing, Published by Prentice-Hall, Inc., New York, N. Y.
3. **Methods of Teaching in Schools of Nursing;** A. B. Brethorst, Published by W. B. Saunders Company, Philadelphia, Pa.
4. **Constructing Classroom Examinations;** Weitzman and McNamara, Published by Science Research Associates, Chicago, Ill.
5. See American Society of X-Ray Technicians manual **Training Aids for Schools of X-Ray Technology,** for other references; $1.15 including postage. Published by The American Society of X-Ray Technicians, Executive Secretary's office, 16 Fourteenth Street, Fond du Lac, Wisconsin.

Chapter XXVIII

RESEARCH IN RELATION TO THE X-RAY TECHNICIAN

(Elective)

OBJECTIVES:

To introduce to student technicians the basic concepts of scientific research; to instill them with a desire to expand their own horizons by planned exploration, and stimulate them to add to the store of human knowledge.

It is suggested that radiologist or some other scientist discuss in one or two lectures some of the attitudes and principles which will whet the students' scientific curiosity and direct their interest toward productive investigation.

SUGGESTED OUTLINE FOR LECTURE: Research in relation to the radiological technician.

Early history of x-ray

The German physicist Wilhelm K. Roentgen, while working as Professor of Physics at Würzburg, accidentally discovered x-rays in 1895 while carrying out a series of experiments to study the conduction of electricity through gases. During an experiment he noted the fluorescence of a barium platinocyanide screen which happened to lie near a vacuum tube through which he was passing a current. He found the rays which produced this effect could pass through objects opaque to ordinary light and also were capable of acting upon a photographic plate. They differed from ordinary light in respect to their reflection and refraction and for this reason he called them "x" or unknown rays. The story of the discovery of natural radioactivity by Antoine Becquerel a year later had several features in common with that of Roentgen. Both men were highly trained in their field. Both were exercising their curiosity to discover new information. Both, like the Prince of Serendip, came upon discoveries by accident and were led to a greater goal than that which they had originally sought. More single-minded or less investigative men might have ignored the glowing plate or thrown away the spoiled photographic plate with a gesture of annoyance.

Some of the earliest use of Roentgen's rays were for research, as in Dr. Walter Cannon's experiments on the function of the intestines of a cat; perhaps the first G. I. Series.

Attitudes of research

An x-ray technician may never take active part in a formal research project and yet his or her daily work is constantly influenced by the attitudes of research. The physician supervising his work has very likely had his training in a center where research is carried out and he brings to his clinical work certain attitudes of research. He is in the habit of regularly attending professional meetings where theories, methods, findings and conclusions are carefully scrutinized and this inevitably affects his attitudes toward his clinical work. If the technician can instill into his work some of the attitudes and aims of research, even "routine" work will not be dull. Some of these are:

1. **BASIC CURIOSITY,** anxiousness to learn. An unusual or unexpected finding should be explained, not passed off as an accident. One should have an open mind toward a new explanation for a group of facts.

2. The attempt to **ISOLATE A PORTION OF THE ENVIRONMENT,** i.e., to set and control the conditions of the experiment. This requires accurate and reproducible technique, and when necessary doubtful findings or possible artifacts should be repeated.

3. **SKEPTICISM OF RESULTS.** An investigator takes into account the number of observations he must have before he may be sure of his results, the variation naturally occurring both in his techniques and in his experimental subjects. He must learn to set up true controls for his experiments. (The concept of a control can be elaborated upon here.) Only after doing so does he state that his findings are "significant." (At this point some elements of medical statistics could be elaborated upon, such as standard deviations, standard errors, etc.) He learns that true objectivity is extra-ordinarily difficult, and that in many lines of research a "double blind" technique, in which neither the patient nor the physician immediately in contact with the patient knows whether a given substance or a placebo is being given.

Relation of research to routine work

For a technician engaged in a research project, the above attitudes must be second nature. In so-called "routine work," the same attitudes are necessary if good work is to be done, as many of the problems are the same. A disinterested technician is a bored one, and one who is slow to learn new techniques. Sloppy technique defeats the work of a department, since, if some findings are questionable, all other findings may be questioned. In evaluating a new technique or type of therapy, the findings in only a few patients cannot be taken as significant.

Ethics of Medical Research

No investigational procedure should be carried out on a patient unless it is known to be innocuous or carries a promise of benefit great enough to outweigh the attendant risks. Where there is risk involved, the patient must understand the risk and give his consent. Many patients will cheerfully undergo discomfort or risk if they realize that by so doing progress may be made in the understanding and treatment of their disease. Many patients will be less uneasy or apprehensive when the subject of any investigation, if they are made to understand what is going on. The chances are that he will be a poor subject if he is treated as a "guinea pig" and not as important collaborator in the work. (More could be put in here about how attitudes of observation and interest can improve the technique of handling routine as well as research patients, by helping them adjust to unfamiliar surroundings and know what sensations they may expect, if not covered in other lectures.)

REFERENCES

1. **Serendipity;** M. J. Rosenau, J. Bact., 29, 91-98, 1935.

2. **Some of the "Do's" and "Do-Nots" in Clinical Investigation;** Fuller Albright, J. Clin. Invest., 23, 921, 1944.

Chapter XXIX

TECHNICAL WRITING

(Elective)

OBJECTIVES:

To create and stimulate in the student an interest in good communication of knowledge through the written word. Learning to write successful manuscripts will help to induce critical thinking on the part of the individual; it will teach the use of books and periodicals for reference which will be of value in his daily work as well as in the preparation of a manuscript; it will challenge the individual to more extensive reading enabling him to keep abreast of his profession and broaden his general background as a person.

Morris Fishbein makes a statement about physicians and writing which is equally applicable to x-ray technicians: "The writing and publication of articles are significant in the development of a successful physician. By these he becomes known outside his own community. Through the reading of papers before societies he makes himself and his work known to hundreds; through his publications, to thousands. Even more important, the writing of an article helps to make the writer better informed on the subject he discusses."

Ideally, this course should be taught by a teacher of English with some technical background. In schools where this is not possible it should then be taught by a physician (not necessarily a radiologist) who has himself been a successful contributor to medical literature, or by a registered technician with the same qualifications. Sixteen hours are recommended as a minimum, one hour per week for sixteen weeks.

During the course, well written articles should be studied, analyzed and criticized. Each week the student should himself prepare for classroom analysis some step in the preparation of an article. Only practice in writing will perfect the writing. It cannot be done by listening to lectures alone.

I. Planning the Paper:

A. Choosing the subject—scope of the paper.
B. Researching the literature—abstracting.
C. Outlining the paper on the basis of the above points.

II. Writing the Paper—first draft:

A. Title—brief, informative, easily indexed.
B. Introduction.
C. Body.
D. Summary or conclusion.
E. Illustrations, tables, charts, et cetera.
F. Bibliography or references.

III. Style:

A. Words—terminology, syntax, simplicity.
B. Sentence construction.

C. Paragraphing.
D. Spelling, punctuation, grammar.

IV. Re-writing—often done many times:

A. Checking accuracy of figures, facts, charts, et cetera.
B. Reading for understandability, simplicity of thought.
C. Illustrations—necessity to finished paper—accurate representation of text.

V. Preparing the Finished Manuscript:

A. Type of paper.
B. No title page—spacing of page 1 to accommodate title.
C. Format—double spacing, margins, et cetera.
D. Preparing duplicate copy for author's file.
E. Proper bibliography.
F. Proof-reading.

REFERENCES

1. **A Guide to Medical Writing;** Henry A. Davidson, Published by The Ronald Press, New York.
2. **Effective Writing;** Sound movie, black and white, 18 minutes. U. S. Air Force, 1952 (Cartoon characters are used to depict the essential ingredients for effective writing. Some of the elements which are discussed are audience analysis, elimination of unnecessary words and phrases, the use of familiar words, the use of action words and the need for proper punctuation. Provides a good review of the writing essentials required to make material easy to read, understand and remember).
3. **Medical Writing; Ed 3;** Morris Fishbein, Published by The Blakiston Division, McGraw-Hill Book Company, Inc., New York.
4. **Paper Writing; an adventure;** Sister Mary Helen, THE X-RAY TECHNICIAN 29:1, July 1957, Published by The American Society of X-Ray Technicians, 16 Fourteenth Street, Fond du Lac, Wisconsin.
5. **The Physician-Writer's Book:** Richard Hewitt, Published by W. B. Saunders Company, Philadelphia, Pa.
6. **Rx for Medical Writing;** Edwin P. Jordan and Willard C. Shepard, Published by W. B. Saunders Company, Philadelphia, Pa.
7. **Writer's Guide and Index to Writing;** Porter Gale Perrin, Published by Scott-Foresman Company, Chicago, Ill.
8. **How to Write Scientific and Technical Papers;** Sam Farlow Trelease, Published by The Williams and Wilkins Company, Baltimore, Md.
9. **The Editor Looks at Writing;** Jean I. Widger, R.T., THE X-RAY TECHNICIAN 30:4, January, 1959. Published by The American Society of X-Ray Technicians.

Chapter XXX

RADIOLOGICAL MATHEMATICS FOR TECHNICIANS

(Elective)

OBJECTIVES:

To provide a review of applied mathematics and to introduce new specific mathematical principles which will allow advanced students to read and understand technical scientific literature related to radiation technology through:

1. Review of applied mathematics at the level attained by the student on admission.
2. Partial treatment of new mathematical principles helpful to the understanding of radiation technique.
3. Practical integration of mathematical theory and its application to routine work.
4. Provision of a basis of knowledge upon which the student may develop a proficiency enabling him to assume additional responsibilities as supervising technician.

While few schools of x-ray technology will feel the need of a course in mathematics at this level, a number of radiologist directors of schools are now offering similar courses to selected students and others have expressed a desire to organize such a course. It is hoped that the course outline which follows may prove of assistance to the directors of schools who wish to offer instruction to students in what to many is a fascinating and valuable subject.

High school mathematics is prerequisite for this course. It is suggested that instructors introduce the slide rule in the first week and give daily problems over the training period. The two text-books listed under "References" have been designed for students of this level of training. Approximately nine hours each year may be devoted to classroom exercises and additional time to written assignments and practical application.

FIRST YEAR

I. Review of Arithmetic:

A. Rules of addition, subtraction, multiplication and division.
B. Fraction decimal notation.
C. Negative numbers.
D. Reciprocals.

II. Percentage and Accuracy Representation.

III. Simple proportion.

IV. Algebra:

A. Algebraic formulas.
B. Addition, subtraction, multiplication, division.
C. Factoring.
D. Equations.

V. Geometry and Trigonometry:

A. Similar triangles.
B. Formulas for areas and volumes.
C. Angle functions.
D. Cartesian co-ordinates.
E. Slope of line.

VI. Graphical Representation:

A. Cartesian co-ordinates.
B. Equation for linear graph.
C. Types of graphs and their uses.

VII. Logarithms:

A. Exponential laws.
B. Basic rules of logarithms.
C. Use of log tables.
D. Application to slide rule.

SECOND YEAR

I. Scientific Notation of Numbers.

II. Logarithms:

A. Logarithm exponential equation.
B. Slide rule.

III. Graphic Representation.

A. Power law exponential relationship.
B. H & D curves.

IV. Special Procedures:

A. Image geometry.
B. Bucky relationship.
C. Body section radiography.

V. Dosimetry:

A. Inverse square law. (Dosage relationship, isotopes and radiation therapy.)
B. Half value layer.
C. Absorption coefficient.
D. Exponential decay.
E. Half life, average life.

REFERENCES

1. **A Student's Radiological Mathematics;** L. A. W. Kemp, Published by Charles C. Thomas, Springfield, Illinois.

2. **Mathematics for Self Study;** J. E. Thompson, Published by D. Van Nostrand Company, Princeton, New Jersey.

Chapter XXXI

CIVIL DEFENSE

Radiological Monitoring for Technicians

(Elective)

I. Basic Nuclear Science:

A. Atomic structure.
B. Ionization.
C. Radiation and radioactivity.
    1. Definition.
    2. Types.
    3. Decay and half-life.
D. Units of measurement, e.g., the curie and the roentgen.
E. Fission and fusion and their application to nuclear weapons.
F. Interaction of radiation with matter (the effect of radiation on matter).
    1. Ionization by alpha radiation.
    2. Ionization by beta radiation.
    3. Ionization by gamma radiation. (Brief, non-mathematical description of the photo-electric effect, the Compton effect, and pair production.)
    4. The effect of neutrons upon matter, i.e., the production of compound nuclei and the emission of radioactive particles and rays.
    5. The relationship between radiation units, dose, and decay.

REFERENCES

1. **Civil Defense Information for Food and Drug Officials;** Published by Food and Drug Administration, Dept. of Health, Education and Welfare, Washington 25, D. C.
2. **Nuclear Radiation Physics;** Lapp and Andrews, Published by Prentice-Hall, Inc., New York, Ch. 4-6.
3. **Radiation and Monitoring Fundamentals for the Fire Service;** Published by International Association of Fire Chiefs Inc., New York Rev. 1955, pp. 13-27.
4. **Radiation Physics and Bomb Phenomenology,** FCDA, TB-11-22, Rev. June 1956.

Films

1. "A is for Atom."
2. "Basic Physics of an Atomic Bomb."
3. "Atomic Energy."

II. Physical Aspects of Nuclear Weapons:

A. FCDA damage zones for various sized weapons.
B. Blast and thermal aspects.
C. Initial and residual radiation.

REFERENCES

1. **Blast Damage from Nuclear Weapons of Larger Sizes;** FCDA, TB-8-1, February 1955.
2. **Civil Defense Information for Food and Drug Officials;** Published by Food and Drug Administration, Dept. of Health, Education and Welfare, Washington 25, D. C.
3. **Physical Aspects,** Charts 1-12.
4. **Radiation Physics and Bomb Phenomenology;** FCDA, TB-11-22, Revised June 1956.

III. Biomedical Aspects of Radiation:

A. Introduction.
   1. Ionization.
   2. Relative biological efficiency.
   3. Theories of mechanism of action.
B. Effects upon biological materials.
   1. Latent period.
   2. Effects on tissues and cells.
   3. Stimulation.
   4. Recovery and repair.
   5. Effects on inanimate objects.
C. Determinants of radiation effect.
   1. Amount of radiation absorbed.
   2. Rate of absorption.
   3. Area exposed.
   4. Species and individual variabilities.
   5. Relative sensitivity of cells and tissues.
   6. Others.
D. External vs. internal radiation.
   1. External.
   2. Action of internal radiation.
   3. Effective half-life.
   4. Natural sources of radiation.
   5. Maximum permissible limits.
   6. Genetic effects.
E. The radiation syndrome.
   1. Acute radiation syndrome.
   2. Chronic radiation exposure.
      a. Carcinogensis.
      b. Genetic effects.
      c. Decreased fertility.
      d. Premature aging.
      e. Embryological and development effects.

f. Cataract induction.
g. Cutaneous effects.

F. Emergency allowable exposures.
1. Acute dose.
a. Emergency services.
b. Population as a whole.
2. Chronic dose.
3. Repeated exposures.

REFERENCES

1. **Annals of Internal Medicine;** Vol. 30, No. 3, part 1., Feb. 1952, Published by The American College of Physicians.
2. **Effects of Nuclear Explosion Upon Drugs;** FCDA, TB-11-1.
3. **Emergency Exposures to Nuclear Radiation;** FCDA, TB-11-1.
4. **Emergency Measurements of Radioactivity in Food and Water;** FCDA, TB-11-9.
5. **Medical Aspects of Nuclear Radiation;** FCDA, TB-11-24.
6. **Permissible Emergency Levels of Radioactivity in Food and Water;** FCDA, TB-11-8.
7. **Some Effects of Ionizing Radiation on Human Beings;** AEC publication, TID 5358.
8. **The Biological Effects of Atomic Radiation;** A Report to the Public of Summary Reports, Published by National Academy of Science, National Research Council.

Film

1. "The Medical Effects of Nuclear Radiation"—21 min. color.

IV. Instrumentation:

A. Principles and types of radiation detection devices.
1. Survey instruments.
2. Dosimeters.

B. Operation of radiation detection devices.

C. Discussion of each of the civil defense instruments, i.e., V-700, V-710, V-720, V-740, V-750, and V-138.

D. Calibration of CD V-700.

E. Calibration of CD V-710.

F. The mechanics and importance of using the dosimeter.

G. Care and maintenance of the instruments.

REFERENCES

1. **Development Status of Personal Dosimeters;** FCDA, TB-11-4.
2. **Instruction Manual for Each Instrument,** e.g., "Victoreen Model 710."
3. **Personal Dosimeters for Radiological Defense;** FCDA, TB-11-2.
4. **Radiation Monitoring in Atomic Defense;** Gray and Martens, Published by D. Van Nostrand Co., Inc., New York, Ch. 9-15.
5. **Radiological Instruments for Civil Defense;** FCDA, TB-11-20.
6. **The Most Promising Dosimeters for Civil Defense Use;** FCDA, TB-11-3.

Film

1. "Radiation Detection Devices."

V. Radioactive Fallout:

A. Production and dispersion of fallout material.
B. Properties of fallout.
   1. The yield of the various fission products (with respect to the atomic weight of the isotopes) from a nuclear detonation.
   2. The types of radioactive fission products.
C. The rate of fall of radioactive material.
D. How weather and winds affect fallout.
E. Fallout plotting.
F. Protection against radioactive fallout.

REFERENCES

1. **Construction of Fallout Plots from Coded Messages Provided by the U. S. Weather Bureau;** AB-188 and Supplements 1, 2, 3.
2. **Facts about Fallout;** leaflet.
3. **Fallout and the Winds;** TB-11-21.
4. **Introduction to Radioactive Fallout;** EG-19-1.
5. **Protection Against Fallout Radiation;** TB-11-19.
6. **Shelter from Radioactive Fallout;** TB-5-2.
7. **The Radioactive Fallout Problem;** TB-19-1.

Film

1. "Atomic Tests in Nevada."

VI. Hazards of Ionizing Radiation:

A. Evaluation of radiation hazards.
   1. The effect upon the body of external radiation exposure.
   2. The effect upon the body of internal radiation exposure.
B. Control of radiation hazards.
   1. The effect of time upon radioactive material (decay).
   2. How the distance from a source of radiation affects the intensity at a given point.
   3. The effect of shielding materials upon radiation.
C. Decontamination.
   1. Surface decontamination.
   2. Aging and sealing.
   3. Removal and storage.
   4. Lab work.

REFERENCES

1. **Atomic Warfare Defense;** Navy Training Courses, NAVPERS 10097, pp. 136-174.
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