These Mysterious Rays

Books by

ALAN L. HART

DR. MALLORY
THE UNDAUNTED
IN THE LIVES OF MEN
DR. FINLAY SEES IT THROUGH
THESE MYSTERIOUS RAYS

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A Nontechnical Discussion of the Uses of X rays and Radium, Chiefly in Medicine

By

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HARPER & BROTHERS *Publishers*

New York *and* London

THESE MYSTERIOUS RAYS

Printed in the United States of America

4 - 43
SECOND EDITION
G–S

This book is complete and unabridged in contents, and is manufactured in strict conformity with Government regulations for saving paper.

PREFACE

THE human being is quite as strange mentally as he is emotionally. His curiosity is as hard to fathom as his passions; the things which do not interest him are as unaccountable as those that do.

For example, people live in light, see with it, would die without it. But how many ever ask themselves what it is? Why do the men and women of our day wear the scantiest possible bathing dress in order to achieve a coffee-brown skin? Why do some of them use money they need more for other things to buy "sun lamps" guaranteed to "build up the blood," tone up their muscles, and make them look like bronzed athletes rather than puny office workers? Why do men sit patiently under "violet rays," expecting their hair to come back? Why do women believe that X rays will remove superfluous hair painlessly, permanently, and safely? Why do people, at sight of an office filled with complicated machinery, leap to the conclusion that Dr. so-and-so is a competent specialist and not a quack?

Such questions can probably never be answered. But there are some persons who ask why and what and where and how. For long I have belonged to that company.

From the day I found that the blazing sunlight of New Mexico might reactivate latent malaria while it was curing certain types of tuberculosis, light fascinated me. From the hour I first looked at stereoscopic films of the skull and found myself a seeing eye in the center of that head, studying it as I might have studied a room in which I stood, X rays fascinated me. From the minute I first saw a tiny capsule of radium shining brightly on a fluoroscopic screen in a darkened room, through the inch-thick wall of lead encasing it, radium fascinated me.

It is not yet fifty years since X rays were discovered. Our knowledge of radium and ultraviolet light is still more recent. Many things had to be learned and much apparatus devised before these mysterious rays could be used, medically or technically. We are still in the process of learning and inventing. But radium and X rays are not the only things which we can use though we cannot control them. Unaffected by our human fatuity and absurdities, these rays go their way—friends if we employ them wisely, dangerous if we approach them ignorantly or carelessly, but fascinating always whether friends or foes.

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CONTENTS

ILLUSTRATIONS

These illustrations, grouped as a separate section, will be found following page 114

These Mysterious Rays

CHAPTER I

A Day in the X-ray Laboratory

IT IS always something of an adventure to go down to the X-ray department of the hospital on Monday morning. Almost certainly there will have been several auto wrecks over the week-end, a few men injured in fights, certain well-fed persons suffering from indigestion following what the Alka-Seltzer program calls "over indulgence," and a handful of people who were ill advised enough to fall sick on Sunday. Monday morning is therefore busy in my department, for while the surgeons are in the operating rooms and the physicians are making rounds and calling on their patients, we try to get our routine work out of the way.

So I arrive in some anticipatory excitement. Miss Randolph, our chief technician, is already on the job checking over the requisitions that have come down early. When I look at her I marvel, as I have been doing these five years, at her air of composure, her unwrinkled white uniform, her smooth blonde hair.

"Good morning. Got a big schedule for today?" I inquire while shedding my coat and slipping into a fresh-from-the-laundry laboratory smock.

"Good morning, doctor," replies Miss Randolph briskly. "I put some emergency films on your desk. You'll want to look at them first. Miss Abbott has a mastoid in the small room, and Miss Fairfax is doing a gall bladder. We have three stomachs this morning—one of them a newborn. Here are your goggles."

I slip the dark red goggles into my pocket and contemplate the calm efficiency with which this young woman manages two assistant technicians, a secretary, the X-ray department of a fairly busy hospital, and me.

In my small private office the stenographer is waiting for me to study the films on my desk—minor emergencies which the internes and resident doctors took care of over Sunday—and dictate the reports which she will presently type and mail out to the attending physicians or send upstairs to be put on the patients' charts. She knows X-ray jargon and the dictation goes rapidly.

It is a motley collection that confronts me—broken bones, abscessed teeth, sinuses full of pus, a chest with some cracked ribs. This is why the roentgenologist cannot be a narrow specialist. In the morning he examines a kidney and a gall bladder, in the afternoon a mastoid and a fractured ankle, tomorrow a chest and a broken head, the next day a stomach and an injured spine. Therefore he must know something about all fields of medicine. Like the laboratory man, with his blood counts and blood cultures and tissues removed at operation, the X-ray man is expected to understand his own specialty thoroughly and general medicine as well.

When I finish the stack of films I lean back in my chair and put on the red goggles to make sure that the pupils of my eyes will dilate by the time Miss Randolph gets my first case down. To examine a stomach, one first observes it in a darkened room on the fluoroscopic screen; the X-ray tube is behind the patient and the rays from it pass through his body to cast shadows of varying density on the screen held between him and the roentgenologist. Thus one can watch the movements of the stomach, its size and shape and the rate at which it empties. After this we make a series of pictures, which show the fine details one might miss on the screen and which also serve as a permanent record of the case.

I hear a voice and look up to see, dimly, the figure of a man in white in the doorway.

"Good morning, doctor. I'd like to look at the baby with you, if I may."

I recall that an infant headed Miss Randolph's list of patients.

"Tell me something about the youngster, Malvern."

The interne assumes professional gravity. "The resident on OB says it was an easy delivery and the child seemed all right at the time—Saturday night. But yesterday he began to vomit. Hasn't kept anything down since."

Then, as he follows me into the fluoroscopic room, Malvern adds with obvious excitement, "If Douglas operates I think I'll scrub up with him. So anything I can find out about the kid will be all to the good."

It occurs to me that possibly young Malvern is that rare phenomenon—a man designed by nature to be a physician, for he has already formed the habit of following patients through their tests to the surgery and the treatment room and—when things go wrong—to the autopsy table.

Miss Randolph is waiting for us. As we come in I close the door and turn off the overhead light, leaving only the faint glow of the shaded bulb on the control stand. On the table a baby is lying with a thin rubber tube dangling from his mouth.

"Are you ready, doctor?" asks Miss Randolph, picking up a syringe filled with a white fluid.

I put a foot on the operating switch. Instantly the screen above the infant springs into pale greenish fluorescence and Malvern and I lean over it, heads together. First we scan the small thorax where everything seems to be normal.

"O.K., Miss Randolph. Go ahead."

A thin stream of white trickles down into the baby's stomach. He is so small that the screen completely covers him; to turn him from side to side, I must fumble beneath it. There is a faint sound—the sucking of tiny lips.

"What's the drink?" asks Malvern. "The kid seems to like it."

"Just barium and water," replies Miss Randolph. "I expect he's thirsty."

"So would we be—and hungry too, if we hadn't had anything to eat or drink since Saturday night," I remark as I pull the tube out of the baby's mouth. His lips cling to it and he wails feebly. I remember how short a time it takes to finish off a newborn who can keep down neither food nor fluid.

Bending over the screen again, Malvern and I watch the white blob of barium in the small stomach. It does not move. We turn the infant over, hoping that the stomach will contract and push its contents on into the intestine. The tiny patient whimpers and, in spite of a hearty breakfast, my own midriff tautens sympathetically.

But the barium does not budge and presently the baby vomits up most of it; we send him back upstairs to the nursery and young Malvern dashes off with my preliminary report. A few minutes later he phones down to say that Douglas, the surgeon, has been called in consultation. I make a note to watch the afternoon surgery schedule.

The next patient is a short, stout, middle-aged man with many layers of fat underneath his skin and a stomach in very high position. Miss Randolph steps up the voltage on the X-ray tube and I poke and prod energetically, but I cannot see the stomach well on the screen and therefore am obliged to make more films of it than usual. This means that the examination will cost the hospital more than the average case—a good deal more, in fact, as I remark when the patient has at last been wheeled away by a student nurse.

"Well, nearly every day we have someone whose stomach is clear up under his chin where we can't tell much about it," replies Miss Randolph philosophically.

The third case is a gaunt young woman out of whose stomach the barium we give her to drink runs with astonishing speed. I ask a few questions and add to my own findings the comment that her stomach should be pumped and the contents examined before she leaves the hospital.

"What do you think is wrong?" asks Miss Randolph with interest.

"Well, whenever I see a stomach dumping like this one I suspect there may be too little acid, or none at all, in the gastric juice. And that might mean pernicious anemia. Of course, now that we have liver extract, that isn't a death sentence, but it's so serious that we don't want to overlook the possibility."

As I leave the fluoroscopic room one of the nose and throat men comes in to look at the films of his mastoid patient whom Miss Abbott X-rayed earlier this morning. We study them together, the mastoid on the good side first and then the other.

"What about it, doctor?"

"The air cells are large but here's a place where you can't see the cell walls at all. I think the bone is necrotic. You'll probably find pus."

Dr. Newtown shakes his head gravely. "If the films will be dry so I can have them in the surgery, I'd like to go in, right after lunch."

I make a second memo for the afternoon. It is a long time since I went wrong on a mastoid but only constant checking of my opinion at the operating table can keep my record clear.

In the corridor of the department I encounter Miss Fairfax, the other assistant technician, and her gall bladder patient. At sight of me the patient's broad fattish face becomes grim.

"That stuff you gave me yesterday nauseated me terribly," she says firmly and reproachfully.

I wonder how much of this reaction is due to the color of the solution we had her drink: blue seems to be a particularly unappetizing hue for anything people are asked to swallow.

"Cheer up," I say. "You'll enjoy your lunch of milk shake with eggs?"

But the fat lady is not amused.

Back in the small waiting room I find what seems at first to be a crowd but eventually turns out to be a shabbily dressed man and woman with three children—a boy about ten, a girl of twelve, and a baby. The man has a note from the county doctor, a brisk intelligent young man who asks me to examine the infant. I notice that the child lies in his mother's lap with his elbows bent and legs drawn up and that he cries whenever he is moved, and I feel there is little doubt that he has scurvy. We make films of his long bones and Miss Randolph takes them into the dark room while I look at the two older children. The girl has four of her permanent teeth left, the boy six; they are all loose and ooze blood and pus when I touch the gums.

Awkwardly the father explains that they came from the Dust Bowl several years ago; starved out on their farm there, they came west and are still working in the fruit, following the crops from place to place. He is thin, his wife is pale, they are worried about their children.

"Seems like I can't get started again, doctor. I don't think the kids get enough to eat; ain't none of 'em really well. And growin' up this way, movin' around all the time, 's a bad idea. But maybe now all this defense work gets under way, I can find me a better job."

Once again in his mother's arms in the only position he finds comfortable, the baby has ceased fretting. I look at his soggy bluish skin and at the scrawny necks and arms of his brother and sister. All three have avitaminosis—complete lack of vitamins—because they live on cereals and potatoes. I am tempted to suggest that the father steal fruit and fresh vegetables for his family. Why, after all, should they work on the land and have nothing fit to eat? But I remember the rising demand for labor in defense plants and hold my tongue.

When I report my findings to the county doctor by phone, he tells me that he has a dentist lined up to make false teeth for the older children and that the relief administration has promised to send them tomato juice and cabbage and oranges. From the telephone I can see the whole family plodding up the hospital driveway toward the street and suddenly find myself wondering about the future of a country where in peacetime children's teeth fall out because of scurvy.

Depressed by these reflections I seize a respite between patients to go down to the laboratory at the other end of the hall where my friend, McDonald, the pathologist, is sitting at his microscope.

"Want to see some fat, swollen pneumococci?" he asks.

I bend down to the eyepiece. There they are—a cluster of those wretched germs, with their protective capsules plainly visible.

"Type 27, believe it or not," says McDonald with obvious satisfaction. "You don't see 27 very often. The fellow's pretty sick, they tell me. If we didn't have the sulfa drugs he'd be a goner, I suppose. But it's an early diagnosis and he'll probably snap out of it all right."

I look down at McDonald—slight, short, unimposing, with fair hair and fair skin and pale blue eyes, but a fighter nevertheless like his Scottish forebears. From the day he set foot in this hospital I have liked and respected him. He is no ordinary laboratory man: behind him he has not only training in pathology but fourteen years of general practice. As young Malvern says fervently, he "knows his onions."

"Sit down a bit. Have a cigarette. I suppose you made films on that youngster with the mastoid?"

"Yes. I think the cells are breaking down."

McDonald nods. "That checks with the blood count we got. And I've got some other excitement for you. A patient of Benson's, a young woman about thirty I believe. She's been sick for three months and in the hospital for almost three weeks without anyone's making a diagnosis."

"Has Benson ruled out TB?"

McDonald grins. "No. That's just the point. He learned to thump chests in the First World War and he's still doing it. I had him in here this morning, telling him he ought to send her down to you. She doesn't cough, she has no pain and no digestive symtoms beyond a little loss of appetite. The urine examination and blood chemistry are normal and the blood count not far off. A perfect setup for TB, as I told Benson. I think he'll send her down some time today, probably."

And indeed, when I return to my own department, the patient is already there. Her waxen skin, her sunken cheeks and hollow dark eyes tell me that she is very ill and, when the exposure has been made, I take the film into the darkroom myself. The five minutes required in the developer, the seconds in the rinse water, and the couple of minutes in the hypo finally drag past and my first glimpse of the film before the viewing light above the wash tank confirms our suspicion. In the upper part of one lung are the scars of an old healed tuberculosis, and scattered throughout the remaining lung tissues there are dozens and dozens of round nodules no larger than grains of rice. From an old infection she never knew she had has now come miliary tuberculosis to spread into all parts of her body. No one can do anything for her; those tiny nodules are her death sentence.

I am pleasantly proud of having justified McDonald's hunch and my own, but glad I do not have to break the news to her family. Even Miss Randolph exhibits a trace of vainglory as she watches the patient being wheeled away on her cart. "It's too bad they didn't think of X-raying her three months ago." But a stern sense of fair play prompts her to add an instant later, "Not that it would have done any good. Only it's nice to know what ails people."

CHAPTER II

A Day in the X-ray Laboratory, concluded

By this time it is noon. The assistant technicians are taking films out of the drier and sorting them into numbered envelopes, Miss Randolph is on the house phone making sure the stomach cases are not given lunch. I pause for a moment to watch the three at their work.

Miss Randolph, who has been with me for five years, looks younger than she actually is, perhaps because she always seems serene and unruffled. Only when we are confronted with a dire emergency does a rising tide of color betray inner excitement, and even then her manner is calm. Under her hands howling infants, frightened children, and nervous women become tranquil. After five years I do not know which is more valuable—her exceptionally fine training or her way with patients.

Miss Abbott was in the department when I came to the hospital. She is small, dark-haired, of uncertain age; she does her job well, keeps to herself after office hours, and shows no desire to go elsewhere in search of change or advancement. It occurs to me that, for all I know, she may be married and the mother of a family. Plenty of married women nowadays work under their maiden names.

Miss Fairfax is a different sort—a cheerful, energetic young woman a bit on the plump side, who has developed into an excellent technician during the eighteen months she has been with us. I note approvingly the care with which she sorts her films and recall her first day as an apprentice in the department.

It chanced that her initiation came on one of these busy Mondays. In the midst of a perfect spate of patients there was brought in a truck driver whose car had been demolished by a switch engine. He was in profound shock and therefore could not be X-rayed then, but since there might be medico-legal complications I promised to examine him later in the day when he was dead and could not be injured by the procedure.

Accordingly, the body was brought down about four o'clock and several films made, after which it was left on the table in a little-used room in the department to await the arrival of the undertaker. Miss Randolph, Miss Abbott and I had all forgotten the new assistant who had been trying all day to keep out of our way and who now, to her consternation, found that she had taken refuge in the room with the corpse. Breathless, she burst in upon me in the dark room.

"Doctor," she gasped, "there's a . . . a dead man out there. Do I have to stay with him?"

I am sure that Miss Fairfax went home that night in two minds about her new occupation; I am sure it was weeks before she was convinced that it is not our habit to leave bodies around the department and that we are by no means as callous to human woe as we seemed to her then. But I know, too, that today she is proud of her job and proud to belong to that little army which stands so stanchly between the living and the menace of disease, although she cannot have forgotten her first day with us.

I smile to myself at this recollection as I wash my hands and go down to the staff dining room where McDonald and I share a table in one corner.

He is not surprised to hear about Dr. Benson's patient.

"Some men never learn that miliary tuberculosis can be found only with X rays."

Presently he continues, "I spent the whole morning doing nothing but giving advice and explaining what my reports mean."

But it is precisely this which makes McDonald valuable. He knows his own specialty and general medicine almost equally well and the staff doctors ask his advice because they esteem it highly.

The pathologist lights a cigarette and watches the smoke with contemplative blue eyes. "I have an autopsy you'll want to see this afternoon," he says suddenly. "That man on Third South we've been wondering about. Malvern got permission for the 'post' from the relatives several days ago."

On our way out of the dining room we stop in my office to look once more at this patient's films. They are worth anyone's study.

The man first came in fifteen days ago, sent by his doctor because he had had a nagging pain in his chest for a week or so. He looked perfectly well and I could find nothing abnormal in his chest on fluoroscopy or on the wet films, but when I studied the films next morning in the stereoscope—a machine which gives them the illusion of a third dimension—I thought there was a little nodule about the size of a pea in the upper right lung. However, I could not make sure of this and, as I told McDonald now for the third time. I had never been more shocked than when I saw the man again ten days afterward. A student nurse wheeled him into the department on a cart, too weak to sit up and obviously very near death. That was not quite a week ago and now McDonald was planning the post-mortem.

We set up the two sets of films I made and compare them:

on the first there is one, poorly outlined, barely visible nodule, on the other there are myriads of dime-sized shadows littering both lungs. And less than a fortnight separates the two examinations.

"You think this thing started in the stomach, don't you?" I ask.

"Yes," comes the answer after a thoughtful silence.

I remember that statement when I stand, a little later, beside the autopsy table watching McDonald remove a stomach which has near its lower end a little stiffened patch no larger than the tip of my finger. And I remember it again the day he shows me his stained sections of that tissue under the microscope. The patient had a stomach cancer so small that it never gave him any symptoms until after it had set its daughter cells adrift in his blood stream to seed his lungs for rapid death.

"Sometimes this sort of thing gets me down," remarks McDonald soberly. "I'm getting into the cancer age myself."

For that matter, so am I, but I have no time to think about it today.

By one-thirty I am in the surgery to watch the operation on the little girl whose mastoid we X-rayed in the morning. As soon as Dr. Newtown chisels through the outer layer of hard bone behind the ear, pus wells up into sight but I wait to see how deep the destruction goes so that I may know just how exact a picture of conditions my report on the films gave him. That done, I hurry back downstairs to look at the grist of films Miss Abbott and Miss Fairfax have put on my desk.

I have not finished this task when Miss Randolph calls me to see the pictures she has been making of a patient who was in a traffic accident on Sunday. High in the spine there are two crushed vertebrae.

I remember the young woman as I saw her lying on the table in the room outside when I came through a moment ago; she was calm and cheerful, and suddenly I realize that she does not suspect that as long as she lives she will never be able to move a muscle below the level of her arms.

"Tough break for a girl of twenty-four," murmurs Miss Randolph, putting the films into the wash water.

Once more in my office I hasten on with my reading, tarrying a little over the films of the baby whose bones are racked with scurvy. "And yet people imagine that scurvy is a disease British sailors had in the eighteenth century," I think.

The phone rings to inform me that they are about to operate on the infant whose stomach would not empty and I go back to the surgical floor where I find young Malvern, as he had hoped, scrubbing up to assist. The resident in obstetrics and I constitute the audience.

When the anesthetist has put the mask over the child's face and work has begun it is almost impossible to see the tiny patient under the big hands of the surgeon and his assistant. But presently Dr. Douglas looks up to say that there is no opening of any sort between the stomach and the small intestine, that each ends in a blind sac and he must devise a connection between them. He is obliging enough to let me study the operative field while he is planning his procedure. Then, having decided what to do and how, he works swiftly with deft sure fingers and in a surprisingly short time steps back and tells Malvern to close up the incision.

"Cases like this aren't very common," says Douglas stripping off his gloves and mask. "I hope the youngster will pull through."

"You'll have to hurry, Dr. Malvern," observes the anesthetist. "The kid's coming out."

(The baby made an uneventful recovery and went home with his mother when he was fifteen days old, none the worse for having come into the world unfinished.)

Going down to the ground floor and my own laboratory again, I lean against the side of the elevator and reflect that it seems a long time since eight o'clock in the morning. The old man at the control lever cocks a wise gray eye at me. "This place," he remarks apparently to the empty air, "can sure take it out of a fellow."

I nod my agreement with this, thinking as I glance at his crooked arthritic fingers that old Amos should know whereof he is speaking. Amos has been in this hospital, in one capacity or another, ever since it was built, and before that he was in the parent institution. Furthermore, while I was still in Buster Browns, he was struggling with the first X-ray machine in town.

In those days X-ray apparatus was something. A huge cabinet higher than a man's head housed disks of mica four or five feet in diameter which were revolved in contact with a set of wire brushes by an electric motor and the current thus generated was led off through bare wires into an X-ray tube. This tube was not like the noiseless ones we use today, but a cranky glass bulb through which Amos was never quite sure he could coax his current. When he closed the switch the generator roared, the tube came aglow, and the uncovered wires spat sparks in all directions. Provided all went well, it was possible to make an X-ray plate of a leg in twenty minutes but of course everything did not always go well.

There was this compensation however: If a usable picture was finally secured, everyone within sight and hearing realized that something extraordinary had been accomplished, whereas in our quiet unspectacular laboratory today there is little to suggest that anything of importance is being done.

Old Amos has never disguised his feeling that he got in on the exciting period of X-ray development whereas I and my generation of roentgenologists are necessarily of softer stuff because untempered by the handicaps he had to face. When he is in an anecdotal mood he can be vastly entertaining and sometimes I envy his experiences. Although he is only a technician I would rather have his opinion on a good many cases than that of some roentgenologists. And furthermore he is never above lending a hand with emergencies at night or on Sundays and holidays.

I hear him chuckling now as he opens the elevator door.

"Don't work too hard, doc, and don't worry," he says. "Tomorrow 'll be another day. And if it ain't, nobody 'll be needin' X rays."

Miss Fairfax is bringing in the films on her gall bladder patient. She explains that she encountered a good many difficulties in the examination. First of all the patient had been nauseated by the blue dye we gave her, and then she had objected to the short hospital gown she was given to wear—an objection with which Miss Fairfax fully sympathized but about which she could do nothing. Finally, she had heartily disliked the egg milk shake she had for lunch.

There is a series of films on the case—each of them with a serial number and the date photographed upon it. I look at the first of the set and see the shadows of three vertebrae and a rib or two, the border of a group of deep-lying muscles —nothing more. There is no gall bladder shadow on the second film and I begin to wonder whether I have misjudged our complaining patient by thinking her a malingerer. Then Miss Fairfax hands me a larger film on which there is a dense oval shadow the size of a small egg.

"What the devil," I begin and then break off and laugh. Miss Fairfax also laughs.

"I almost missed that one," she says. "We haven't had a patient who was turned around for a long while."

The trouble was simply that the plump lady wore her heart and stomach on the right side and her gall bladder on the left. Once we had located her gall bladder we could see that it behaved properly; it filled on schedule and emptied after fatty food as all well-conducted gall bladders should.

And so the day ends on a note of pleasantness. To be sure, there are the half-starved family of fruit pickers, the gaunt young woman whom I suspect has pernicious anemia, the woman with generalized tuberculosis, and the man who has died of cancer in his lungs. But, on the other hand, there are the little girl whose mastoid has been cleaned out, the baby whose stomach has been connected with his intestine, and now the patient whose gall bladder has been cleared of suspicion. On the whole, the day might have been worse—much worse.

Not more than a handful of our patients understand why they are X-rayed; for the most part they expect the impossible or nothing at all, having no idea of either the importance or the limitations of X-ray examination. Few of them realize the protection afforded by this type of study. For instance, the husband of the woman who is dying of miliary tuberculosis will not thank us for the diagnosis and yet it is a timely warning for the other members of her family to look to the state of their own health. The father of the little girl whose mastoid was operated on will think of her X-ray films only when he finds them on his hospital bill and certainly the family of the man who died of cancer of the lungs will never be grateful to McDonald or me for finding out what was wrong with him.

And yet it may be that in the end someone no more distinguished than we will discover the cause of cancer, or it may be that the sum of the little knowledge of us all will be added up by some genius into a cure for the disease. Meantime, we do our bit in the never-ending struggle between life and death and reap our inconspicuous rewards, for our inconspicuous work. We even have our own peculiar pleasures, not least among them the occasional discovery of something utterly unsuspected or perhaps amusing.

All detectives are not found in police departments or private agencies or even in the ranks of those gifted amateurs whose exploits are so beguilingly described by Dorothy Sayers, Ellery Queen, Leslie Ford and company. I think no one could work long in an X-ray laboratory without feeling himself a sort of detective; for where other doctors must make diagnoses by observing symptoms and reactions and by examining the patient's body fluids, the roentgenologist finds out what is wrong by literally looking through people and making photographs of the hidden details of bones and lungs and brains.

Sometimes the things he discovers are somewhat ludicrous. I remember a man whose spine and pelvis I once examined, who told me, when I had finished, that he had no money and could not pay me for my work until he collected his accident insurance. I asked the technician to bring me the film of his pelvis and pointed out on it the shadows of several silver dollars.

"Don't tell me you haven't any money," I said severely. "Look what's in your right-hand trousers pocket."

The disconcerted man silently produced a purse and paid my fee. For once I did not reprimand the technician for not getting all a patient's outside clothing off him: the three silver dollars in that pants' pocket had saved me more than five times that amount.

Another odd affair concerned Mrs. Montgomery's beauty pin. I was a cub then, serving my apprenticeship in a famous X-ray laboratory and very proud to have been entrusted with the preliminary study of patients. But this was a stifling summer afternoon before the days of air conditioning, and Mrs. Montgomery was the last of a long succession of patients at whose chests I had been peering on the fluoroscopic screen. I was hot and tired, and I did not see why it was necessary to examine the hearts and lungs of people whose complaints were all below the diaphragm. (The notation on Mrs. Montgomery's chart read "Suspected gall bladder disease; questionable stomach lesion.")

Annoyed at the prospect of one more useless—so it seemed to me—examination but powerless to deviate from the prescribed routine, I sat back and mopped my face while I waited for the patient. Presently I saw her coming across the dimly lighted room, an indistinct blob of white in the company of another blob which I knew to be the department nurse.

"This is Mrs. Montgomery, doctor," said the nurse.

I mumbled some response. Being introduced to someone whom I could hardly see and who could not see me at all because her eyes were not yet accommodated to the faint red light struck me as another absurdity.

The nurse guided Mrs. Montgomery to her place behind the fluoroscopic screen and I stepped on the foot switch. Instantly the red ceiling lamp went out and the screen before me sprang into a faint greenish glow. Mechanically, I followed the routine: the size and shape of the thorax, the apices of the lungs, the position of the trachea (windpipe), the state of the lymph glands in the center of the chest. They all appeared to be normal. Then I pushed the tube and screen downward to look at the heart and diaphragm. I stared for a moment, then spoke to the nurse with a voice which I hoped was calm and unvexed.

"Miss Jones, will you please take Mrs. Montgomery back to her dressing room and see that she removes *all* clothing down to the waist?"

In a few minutes the two women returned and the nurse reported that Mrs. Montgomery had undressed properly in the first place. I had another look at her chest, then plucked her from behind the screen and went over her myself. Except for her shoes and stockings she had on only the cotton gown all X-ray patients wore.

But in the base of her left lung was a pin. I saw it distinctly on the screen; it was a beauty pin of the sort I had often seen on my mother's dresser when I was a child. I was so excited over discovering my first unsuspected foreign body in a lung that I almost forgot to send Mrs. Montgomery on to the man who was waiting to examine her stomach.

And she was as surprised as I. She had no idea how a beauty pin could have got into her chest. Not until we wrote her mother was the mystery solved.

The mother said that when her daughter was about fifteen months old a gold pin thought to have been in her dress had disappeared. For some days after this she had searched the baby's diapers and, having found nothing, concluded that she must have been mistaken. It had never occurred to her that the child might have inhaled the pin, and since the baby had no symptoms the whole affair was soon forgotten.

The tiny bauble must have slipped down easily and found itself a niche in a bronchial tube where it did little harm because, at the age of forty, Mrs. Montgomery still had no symptoms. But now that she knew she had a pin in her lung she was unhappy until it was removed with that remarkable instrument, the bronchoscope, invented by the American medical genius, Chevalier Jackson. And strange to say, the gold trinket was in very good condition despite its years inside a human thorax.

Of course this sort of thing does not happen often. For the most part, we roentgenologists follow a familiar and rather stereotyped pattern of existence.

At five o'clock or thereabouts we close our files, turn off the lights, and shed our office uniforms. Miss Randolph and Miss Fairfax leave together with a cheerful "Goodnight, doctor." Miss Abbott slips out alone, more quietly. I close and lock the door of the waiting room behind me. The light from the overhead lamp in the corridor glints on the metal sign—"Radiological Department."

I hear the clang of the elevator door and, as I hurry down the hall, old Amos calls after me, "Good night, doctor. I hope you won't have to come back tonight."

But I know that I probably shall come back. I always know that my working day is probably not over when I leave the hospital before dinner. Any night may bring its man shot through the head, its child crushed by a speeding automobile, its woman gasping with pneumonia. And when they come we must be ready.

CHAPTER III

Radiology Comes of Age

It is not yet fifty years since Wilhelm Konrad Roentgen, then a relatively unknown professor of physics in the University of Würzberg (Germany), discovered X-rays. He announced his achievement in January, 1896, and, since the Crookes' tube which gave off these mysterious rays was already a familiar object in physics laboratories, scientists all over the world were soon photographing keys and watches and bones. Newspapers and magazines were full of cartoons and humorous comments on the amusing and embarrassing consequences of being able to see people's skeletons and the contents of their pockets through their flesh and clothing. *Punch,* for example, had this to say of Roentgen's discovery.

> We do not want, like Dr. Swift,
> To take our flesh off and pose in
> Our bones, or show each little rift
> And joint for you to poke your nose in.

Little more than two years later the Curies—Pierre and Marie—discovered radium. Scarcely had they done so than a whole covey of research men began to ferret out the mysteries of this new element, so closely allied to X-rays.

It was, of course, inevitable that both X-rays and radium should be used in medicine. Any form of radiation able to penetrate the human body and produce photographs of the tissues it passed through was palpably an excellent way to examine patients; indeed Roentgen had hardly announced his discovery when it was suggested that the new rays might be useful in the study of the stomach at work. As for radium, Pierre Curie and Henri Becquerel soon found that it had a destructive action on the skin and it was only logical to assume that a substance which could destroy normal tissue could also destroy cancer.

But you must remember that in 1896 no one on earth had any idea what pneumonia or tuberculosis of the lungs, for instance, would look like on a photograph and that no one knew much more about the habits of cancer cells. So it was necessary, before either X rays or radium could be used successfully, to accumulate a store of experience and many records where the diagnosis had been proved in the surgery or at the autopsy table. And it was also necessary to improve the machinery for generating X rays.

It would be hard to imagine two more mulish and erratic pieces of equipment than the static machine and the X-ray tube of the nineties. The huge noisy generators were inefficient; the tubes, besides being short-lived, emitted only a few rays and they could not be focused sharply enough to give a clear-cut image. In those days it took an exposure of ten minutes for a chest plate and, since no one could hold his breath that long, it was impossible to get sharp lung detail with even the most co-operative patient.

Not until 1908 did an American—H. C. Snook of Philadelphia—build an efficient transformer for X-ray laboratories and not until 1913 did another American—Dr. W. D. Coolidge of the General Electric Company—develop a dependable and convenient tube. With these improvements, however, came an end to the very long exposures which had hitherto been unavoidable. Thereafter technical development became rapid and continuous.

But in every field there is a lag between knowledge and performance; we nearly always know better than we do. Several years passed before all the old X-ray machinery was discarded and all our old careless habits cast aside. I can remember how, when I began dabbling in X-ray work, almost all darkrooms were understairs closets in which the unfortunate roentgenologist could stand up only near the door and had to crawl on his hands and knees to reload his holders with fresh films from the bin at the far end of his murky den. It was quite an innovation when some X-ray men put strips of felt around the edges of the door to keep light from reaching the films they were handling and built lead-lined boxes in which they could store unexposed films in their workrooms. Very sharp in my memory of the small hospital in which I, a young physician fresh from a general country practice and quite devoid of any knowledge of roentgenology, had turned over to me a clumsy, poorly constructed X-ray outfit which roared and sparked so viciously that I was almost as terrified by it as my patients were. So inadequate was the insulation of this machine that I kept two buckets of water in one corner of the fluoroscopic room within easy reach should actual flames appear. I hope none of the stomach cases I examined in that room were as uneasy as I was whenever the odor of overheated wood arose.

I literally studied my patients book in hand. The few texts on X rays that were then available I bought as soon as I could afford to and over them I pored anxiously in my spare time. By this means and by trial-and-error I learned a good deal but I used to wonder if the patients got their money's worth. But I do not feel guilty of unprofessional conduct because of this experience: in all that sprawling western state in which I lived there were not then a half dozen doctors who knew more than I did about X-ray work. And by putting our heads together and adding up all our bits of information we used to find out a great deal about our patients.

It was during the First World War that roentgenology came of age. By that time enough experience had been accumulated to make X-ray diagnosis reasonably accurate and efficient apparatus was available. Not only did the mobilization of huge armies and the needs of military hospitals increase the demand for X-ray work but many physicians learned something about X-ray interpretation. Until then they had had to study pneumonia by listening to their patients' chests or examining their lungs in the deadhouse, but now they could see photographs of every stage of the disease in the living person.

Naturally when these doctors resumed practice after the war they wished to continue using this tool which they had found so valuable in military medicine. Many of them now realized that frequently they could *see* disease in the early stage when it produced no definite symptoms, that an X-ray plate of the chest would usually show cloudiness in the lungs twenty-four hours or more before physical examination disclosed pneumonia, that X rays would often reveal tuberculosis of the lungs before anything abnormal could be heard with the stethoscope or the patient had realized that there was anything wrong.

It would have heartened the pioneer X-ray men, struggling in their cramped ill-ventilated darkrooms with large clumsy glass plates, cutting their fingers on the sharp edges and finding the plates cracked in the storage files in spite of all precautions, to know that by 1920 flexible film would have replaced glass. Handled with resonable care film neither cracks nor breaks; it is easy to store; and the type now in use is no more imflammable than ordinary paper.

During the twenty's and thirty's there was a great increase in the number of X-ray machines used in the United

States and there were many improvements in both the equipment and the art of using it. The greatest lag now came to be in the professional skill necessary in handling the apparatus and interpreting the findings. Many physicians who could not afford long absence from their offices took short courses in the hope of using X rays to better advantage in their private practice, and graduate schools of medicine and famous hospitals began to offer two and three-year periods of special training in radiology. A new group of laboratory assistants came into being—the X-ray technicians. Many of them are women, some of them nurses. Their job is to make exposures, to develop, file and index films, to assist in X-ray and radium treatments; but, as I know from experience with Miss Randolph, they often do much more than that.

When I see photographs of Roentgen's original little pear-shaped tube and of the cumbersome static machines and induction coils with which the early roentgenologists struggled and then think of our quiet compact convenient apparatus at the hospital, I am inclined to agree with old Amos that he did indeed live in the exciting period of X-ray development and that my generation of roentgenologists should be properly humble before him and his contemporaries. Those pioneers, hampered by poor equipment, illustrate something that is in danger of being forgotten in America today: the man is more important than the machine with which he works. It is comparatively simple to build a transformer or an X-ray tube, now that we know the principles on which they function, but it takes many months to train a technician to use them skillfully and years to teach a doctor to interpret what he sees with them and how to use them safely in treating patients. Rome was not built in a day, we are told; neither is a competent radiologist made in six months.

There are only some 180,000 physicians in the United States and only about 2,500 of them are experts in radium and X rays. The country could find use for many more radiologists in 1942, to meet the needs of our armed forces, our defense industries, and our civilian population, but the war—let us hope!—will be over before any considerable crop of these highly trained specialists can be turned out by our teaching hospitals and graduate schools of medicine. Four years in medical college, one or two years of hospital work, a background of medical practice, and two to four years of post-graduate training—that is what it takes to make a radiologist who is worth his salt. This is no path for the man to take who is looking for a pot of gold to be found by walking over to the end of the rainbow.

CHAPTER IV

The Roentgenologist Studies Bones

MRS. BLAKE drew herself erect in her chair and glanced at her husband with definite exasperation.

"There isn't a thing wrong with me except some black and blue spots," she declared.

"But your neck is stiff. You told me so yourself, at breakfast. And after all, the car did turn over three times."

Mrs. Blake made a gesture of resignation and sighed audibly.

"You can see, doctor, that it isn't Leonard's fault that I'm not a neurotic woman filled with imaginary aches and pains. But now we're here I suppose I might as well go through with it. What do you want me to do first?"

As she rose to follow Miss Randolph from the room I noticed that Mrs. Blake carried her head a bit stiffly and a little to one side.

"My wife doesn't like to admit sickness or injury," said her husband apologetically. "You see, she's been playing with Christian Science. And then, of course, she's always busy."

I looked at Mr. Blake with some interest, wondering momentarily whether this quiet-voiced man liked being married to an energetic business-woman. But I forgot my curiosity about the psychological quirks of the Blake family as soon as I saw the films Miss Randolph showed me a few minutes later.

"Call the office and see if Dr. Douglas is in the hospital," I said. "This woman has a broken neck and doesn't know it, and if we don't get her into the hands of a competent man she'll go to some quack or faith healer."

Between us Douglas and I finally convinced Mrs. Blake that she had a crushed vertebra and must have something done about it, and for several weeks afterward we had the satisfaction of seeing her around town wearing a steel-and-leather collar but going about her business as usual, to the astonishment of those people who imagined that a broken neck would be fatal.

Some months later when I happened to be at a dinner party which the Blakes also attended, one of my fellow guests mentioned the matter to me.

"I always supposed if a fellow broke his neck, it was curtains. But look at that woman. She didn't miss a day's work and to look at her no one would suspect anything had happened to her."

"You can't tell by the looks of a frog how far he can jump," I answered, remembering that clichés are often useful in conversation.

But that very thing is extremely hard to get into people's heads. If a victim's arms and legs are not dangling at right angles or if he is able to stand up and stagger around, the average person will think that he is not badly hurt. Even those whose work brings them frequently into contact with accidents and violence fall into this error.

I remember being called to the hospital one night on an emergency, soon after young Malvern began his interneship. When I reached the accident room I found a man sitting bolt upright on a straight chair, guarded by two policemen. In the background hovered a nurse and Malvern was bending over the patient, his face perplexed.

The officers' story was that they had been on their regular rounds in a prowler car when they picked up a call to go to a certain address in a residential district. There they found their prisoner lying on a lawn under a tree, with a revolver beside him. The lady of the house explained excitedly that she had heard a shot, looked out and seen a man weaving about in her yard, and promptly called the police station. The two officers had loaded the man into their car and brought him to the hospital, but they scoffed at the idea that he had really shot himself.

"He fired into the air and then banged the side of his head with the butt of his gun to make it look like he'd been shot," said one of them.

I glanced at Malvern inquiringly. He flushed a little.

"I'm not sure," he explained. "There's a good deal of swelling and . . . "

I examined the patient's temple for myself. It was bruised and doughy but I could make out no bullet wound, and there was none on the other side.

All the while the prisoner sat stiffly on his chair, saying nothing and giving no sign that he was aware of what we were doing. His pulse and breathing were a little rapid, but of course that might be due to fear.

"You can't tell us anything about these birds," said the second officer. "They're always tryin' to put something over."

I felt it would be a waste of time to reply. We would soon know whether the policemen were right. But I had the nurse get a stretcher and Malvern and I helped the patient lie down on it. Then we propped a film holder up alongside his head and made our first exposure.

Before I took the films over to the darkroom in the X-ray department I looked at the prisoner once more. There was apparently no change in his condition but there was something about his face I did not like, and so I warned Malvern to watch him closely.

As soon as my films began to clear in the hypo I violated all principles of good darkroom technique by peeking at them. There, splotched across them, were the irregular fragments of the bullet which the patient had fired into his brain an hour ago. Before I could put the films back into the tank, the extension phone rang; it was young Malvern calling to report that the man had suddenly gone bad and that he had sent for a surgeon. By the time I reached the accident room again, the patient had become unconscious and within another hour he died.

I have seldom seen Malvern more impressed; for days afterward I heard him telling the other internes about his experience.

"Believe me," he said over and over, "that taught me something. I'll never take it for granted that a fellow hasn't shot himself just because he can walk around and I can't find the hole in his head."

Whenever I heard Malvern say this, I chalked up another milepost in the training of a good doctor. It is never safe to pass up any injury as trivial until it is proved to be so. This, as I explain to our internes, is why we always X-ray the children whose frantic mothers bring them in because they have run their hands or arms into a wringer, although very few of them actually have broken bones.

Fractures

Today X-ray examination of fractures is so much a matter of routine that we are apt to forget that until 1896 doctors had to set broken bones by the feel of them. Even though they had only their fingers to see with, many of these old-time physicians were marvelously shrewd in diagnosis and marvelously clever in treatment, but it is obvious that however skillful they were without X rays they could have done a better job with them.

The examination of fractures is usually a simple procedure. Some patients imagine that the X-ray laboratory is a dangerous place and that they are going to be hurt, but nothing is farther from the truth. Of course a broken arm will not stop paining you because it is being X-rayed, but neither will it hurt any worse.

Our personnel have learned to move accident cases gently and handle all fractures carefully in order to avoid making a bad matter worse. Too often first aid does more harm than good. Picking up a man with a broken back by the head and feet so that he sags in the middle will increase the deformity of the injured vertebra and standing up or sitting may do a great deal of harm. Any patient whose injury involves more than an arm or ankle should always be moved on a cart or stretcher and never put into a wheel chair or allowed to walk.

Now, suppose you yourself came into our department with a broken leg. What would happen?

First of all, you would be lifted on a wheeled stretcher and laid down on your back. The clothing would be removed from the injured leg. Then Miss Randolph would push up alongside your cart a piece of apparatus consisting of an upright mounted on castors, on which there is a black housing some eighteen inches long with a heavily insulated cable entering it. Inside this housing, if you cared to ask, she would tell you there are a transformer and an X-ray tube. The whole apparatus is so well protected that it is impossible to get a shock from it even if you touch it.

From a wooden cabinet (lined with lead to keep out the X rays), Miss Randolph or one of the other technicians would produce a thin flat metallic receptacle somewhere between twelve and eighteen inches long and about an inch thick. This is the casette; it contains the film. It is slipped gently beneath your leg, and on one corner of it is laid a metal disk containing in perforated letters and figures the date and your serial number.

This done, Miss Randolph will retire to the corner of the room where there is a black cabinet, not quite waist-high, covered with levers and dials. She moves the indicators, choosing the voltage and amount of current she wishes to use, as well as the time of exposure. Then she presses a button. You hear a faint buzzing sound for an instant, she slides the casette out from beneath your leg, and the job is half done.

However, we must make a second film of your leg from the side in order to know exactly how much deformity you have. For, in case the upper fragment of bone should slip down directly behind the lower fragment, we can see this displacement only from the side.

To get this lateral film, the technician will very carefully slip thin bags of sand under your heel and the back of your leg and knee, and prop her casette edgewise alongside the limb. Then she will turn the tube housing around so that it points at the side of your leg. After this the second exposure is made. Your ordeal is now over and you have been neither frightened nor hurt.

About ten minutes is required to develop the films and clear them enough to make sure they are of satisfactory photographic quality. If there is a fracture we can usually see it at once, on the wet films in the darkroom, but slight breaks or injuries to the small bones of the hands or feet can often be found only on dry films or films made at several different angles.

When we have a patient suspected of having a fractured spine we make one film with him lying flat on his back and then we roll him over on one side very carefully and make a lateral exposure. No examination of the spine for either injury or disease is complete without such a lateral view.

People who have a broken pelvis are usually in a good deal more pain than those with spinal fractures of the ordinary sort and so we do not attempt to move them off their backs. Instead we make what we call stereoscopic films. That is, two exposures are made with the patient lying quiet but with the tube shifted a few inches between the exposures. These films are put in the stereoscope—a machine with a system of reflecting mirrors—and when we study them we get the impression of a third dimension (thickness). It is just as though we were standing in the center of the pelvis, looking around as we would do inside a room. Such films are also useful in many other conditions and parts of the body (e.g. skull and chest).

Bone Diseases

Bones are examined for disease as well as for fractures. Tuberculosis, for instance, often attacks the joints—especially in children and young people. Here as elsewhere in the body this infection creeps slowly upon its victims, producing few symptoms or confusing ones. Thus, tuberculosis of the hip often causes pain in the knee and tuberculosis of the lower spine may produce an abscess in the groin. However, the disease shows such characteristic changes on the X-ray film that there is usually no question about the diagnosis. I have seen children recovered from tuberculosis of the spine who showed years later, on X-ray films, shadows as large as my fist where vertebral abscesses had healed and calcified.

The acute infection of bone with pus-producing bacteria, known as osteomyelitis, behaves quite differently. Unlike tuberculosis it comes on with severe pain and high fever, but for several days after its onset there are no visible changes on the X-ray film. It is often nearly two weeks before definite X-ray signs appear; before then the alert surgeon will have started sulfonamide drugs and/or have drained the infected area.

Syphilis is another infection which affects the bones in many cases. Babies born with syphilis show characteristic X-ray findings and many adults who acquire this disease also have bone changes. Several years ago I was studying in a research institute located in a foreign quarter of a large city where there were many people who could not afford good medical care. Along one side of our X-ray room there was a row of booths where patients undressed before they were examined. For reasons of economy these booths had curtains instead of doors, and because they had to be washed over and over the curtains shrank steadily.

This particular afternoon I came in and stopped in my tracks to stare at the pair of legs I saw below the lower border of the curtain of the booth in front of me. A moment more and the legs came out and started toward me. Never before and never since have I seen such a pair of shins. The patient had had rickets in her childhood, and this had made her very bowlegged. Besides this, she had had syphilis and this had caused the bones of her legs to bow forward and to thicken. (This is called a "saber shin.") The combination of these outward and forward curves, all moving toward me as the patient walked across the floor, was more nearly indescribable than any other deformity I have ever seen.

Thanks to radio everyone has heard about vitamins, but everyone does not get enough of them, as witness the family from the Dust Bowl in chapter one.

Rickets results from a deficiency of vitamin D and scurvy from a deficiency of vitamin C in the diet. Both diseases commonly affect young children, and each causes characteristic changes in the bones.

In rickets the lack of vitamin D causes a decrease in the calcium content of the bones, which therefore are softer than normal. These soft bones become deformed as the result of muscle pull and the positions the child habitually assumes. Thus we have bowlegs, pigeon breasts, and square heads flattened in the back. Rickets is easily recognized on X-ray films of the long bones and even after it has healed there are telltale signs for many years in the bony skeleton.

Rickets is not painful. Scurvy on the other hand is extremely painful in the acute stage. It causes hemorrhages to collect around the bone underneath the covering membrane (periosteum), and this and other changes in the growing portions of the bones can be recognized at once on good films of the legs and arms.

Bone Tumors

Bone tumors are another important group of diseases which must be chiefly diagnosed by X-ray examination.

Anything that grows on you or inside you that does not belong there is a tumor. In one sense an unborn baby is a tumor. But all tumors are not alike, just as all people are not alike. Some people are good citizens and some are criminals or gangsters. So there are benign tumors and malignant tumors (or cancer).

Benign tumors do harm only through their side effects. For example, there is not room enough inside the skull for the brain and a tumor; hence any brain tumor will cause symptoms because it increases the pressure inside the head. Another common benign tumor is the uterine fibroid which produces symptoms because it causes bleeding and may become very large. But neither the fibroid nor the benign brain tumor influences the patient's health directly.

Malignant tumors, commonly called cancer, behave very differently. They have three dangerous characteristics: (1) they cause the patient to lose weight and strength and become anemic; (2) if partially removed they come back; (3) they turn adrift into the blood and lymph of the patient's body daughter cells which find their way into distant organs and grow and flourish there. Malignant tumors will not stay put. The original parent cancer is called the primary tumor; the daughter cancers which spring up elsewhere are called metastases, and the process of spreading in this way, metastasis.

Both benign and malignant tumors occur in bone. The benign tumors of course are much less troublesome than the malignancies, but there are varieties of benign bone tumor that are large and produce great deformity and there are other types which cause the bones to become so fragile that they break at the merest touch. Still others are near joints and interfere mechanically with movement, and some are simply spurs or projections from perfectly normal bones and cause no symptoms at all. Whether benign tumors should be removed depends not on their existence but on their location and size.

Although they are not well known to the public there are a good many malignant tumors of bone. Those which originate in bony tissue are usually called "sarcoma." Remember that word; it might be important for you to know it one day.

Sarcoma develops more often in children or young people than in the middle-aged or elderly. Not infrequently these tumors appear in the shinbone or thighbone after some such injury as a kick in a football game; they do not often develop following severe injuries or fractures. They are dangerous and likely to result in early death if not treated promptly and expertly. Amputation may be necessary; if indicated, it should be done quickly. Oftentimes the treatment must combine surgery, X ray, and radium. Even at best the results are often bad.

When daughter cells of some cancer elsewhere in the body lodge in bones, secondary or metastatic tumors develop there. Practically any cancer can do this at times but those which most often spread into the bones are cancer of the breast and prostate. The bones most frequently involved are the vertebrae, the pelvis, the ribs, the skull, and the thigh bones. The hands and feet are seldom affected.

Usually by the time a cancer has metastasized into the skeleton, the outlook is hopeless and little can be done beyond relieving the patient's pain. In perhaps half the cases this can be done with X rays.

All radiologists sometimes encounter the distressing situation of a patient whose parent cancer caused few symptoms and who comes in for medical advice only after the disease has invaded the bones and intractable pain has set in. I remember a tall fine-looking old man who once came to see me about a persistent sciatica. He told me he had been perfectly well so far as he knew until a few months before when he developed a pain which ran down the back of his thigh. He went to a doctor who said he had sciatica, gave him medicine to take, and asked him to come back if he did not get better. For a little while the patient thought he improved somewhat, but soon his pain returned as bad as ever. The doctor then suggested an injection of the sciatic nerve, but the old man did not like this idea and after a few weeks he consulted a chiropractor who made a diagnosis of a misplaced vertebra. For a time his treatment too seemed to bring improvement but before long the pain was back worse than ever.

When the patient came to me he could sleep only in short snatches after taking five or six aspirin tablets at once, he was thin and haggard and very much worried. X-ray films of his spine and pelvis showed extensive invasion by cancer. Not only could we say that the condition was cancer but also that the parent tumor was probably in the prostate —a diagnosis later found at post-mortem to be correct. Of course the disease had gone too far for us to attack the primary growth, but X-ray treatment gave marked relief from pain and the old man's last months on earth were fairly comfortable.

It is curious that both cancer of the breast and cancer of the prostate give such characteristic bony metastases that one can locate the primary tumor by seeing the X-ray films of the spine and pelvis. But several other kinds of malignant tumor also habitually behave in ways that make their recognition easy. Some years ago I had a dramatic example of this.

In the city where I was then working there was a surgeon who was none too scrupulous in his practice and none too accurate in his diagnoses and whom therefore the other doctors in town distrusted. One day this man called me up to say that he was sending in for X-ray examination a patient who had a bad kidney which he planned to take out in a day or two. Since on an earlier occasion this surgeon had removed a kidney only to find that it was the only one the patient had, I thought he had learned his lesson and had resolved to do better.

To my surprise I discovered his new patient had two kidneys, each of them perfectly normal from the X-ray standpoint, but that the lower spine showed many small areas of bone destruction. We immediately made films of the man's thorax and head and pelvis and found similar bone destruction in all these regions. The appearance was typical of a disease called multiple myeloma for which there is as yet no cure.

Our X-ray examination therefore saved the patient the ordeal of a useless operation, a large surgical fee and hospital bill, and also increased the estate he left to his family a few months later.

The responsibility of the roentgenologist in the diagnosis of bone tumors was impressed upon me early in my career by the chief of the radiological service in the hospital where I was studying. Late one winter afternoon one of the staff surgeons rushed into the X-ray department with some films in his hand.

"Take a squint at these pictures, will you?" he exclaimed, "while I go upstairs to look at the surgery schedule. It's sarcoma and probably too late to do much. Kid fourteen years old, sent in from a little town down the valley. Kicked in the thigh last fall playing football. Soreness and swelling ever since but never went to a doctor until last week. Boy and his father came into my office today with these films."

With these disjointed comments the surgeon dashed off. My chief sat down to study the roentgenograms and motioned me to join him. To our dismay we saw three small stained blotched films of such poor quality that we could barely see a mass protruding from the side of the thighbone about four inches above the knee. The chief shook his head.

"Gregory is a clever operator. He could be one of our best bone men if he'd take time to read and study. But anyone who knew the first thing about X ray would realize that these films aren't fit to make a diagnosis of anything on. He mustn't take that boy's leg off tomorrow."

I had a date that night but I did not keep it, for when the chief at last persuaded Dr. Gregory to consent to further examination it was dinnertime and he sent the technicians away, saying that he and I would take care of the lad. At his direction I made exposures from many angles and with all manner of technical variations, to secure different qualities of photographic detail. Then I developed the films and made a few more at still other angles and distances.

While I was in the darkroom the chief talked to the boy and his father, getting an accurate history of the injury and the symptoms which had followed it. At seven o'clock he sent the patient back upstairs and told me to go and get my dinner while he went home to eat.

While I ate the films washed. As soon as I came back from the dining room I put them in the drier. At ten o'clock the chief returned to the department and sat down to study them. I watched him as he wrote down a list a page long of possible diagnoses and then, one by one, ruled them out.

"You see," he said, "the boy's fourteen. That rules out this . . . and this. The growth is on the shaft, not at the end of the bone. That eliminates this other possibility. The pain has been constant but not severe enough to keep the youngster out of school. The cortex of the bone isn't destroyed, you can see the border right through the tumor. There are no spicules of bone standing at right angles to the shaft on any of the films."

And so he went on, showing me all the things he saw on our films and telling me why he discarded one by one the possibilities he had on his list. Finally at midnight he had come to a conclusion; he wrote a report in longhand which he asked me to take upstairs to put on the patient's chart while he called Dr. Gregory on the phone.

"He won't try to bulldoze me," explained the chief. "I've kept him from pulling too many boners, and he knows it."

The next morning I stood in the surgery watching Gregory open the boy's thigh. The tumor proved to be what we had suspected—a collection of blood which had formed after the football injury and which had gradually hardened and partly turned to bone. It was possible to remove it and scrape the femur clean. The boy recovered rapidly, went home in ten days, and has never had any recurrence of symptoms.

I learned several things from that case. One of them was that neither the patient nor his father had the least idea that they owed the preservation of the boy's leg not to the surgeon who operated but to the quiet man in the basement X-ray room. Another was how much it meant to have one's training under a man of the caliber of my chief.

CHAPTER V

The Roentgenologist Studies Lungs

Johnny Has a Dry Spell

One busy Saturday morning Miss Fairfax put her head into my office and looked inquiring.

"Yes. What is it?" I asked.

"Johnny Miller is here for his regular film," she began.

"Well, go ahead. You know what I want—just an ordinary flat chest film and then a lateral with his right side against the casette."

"Yes, but he wants to see you first. He says he has something important to tell you."

I sighed. Johnny was getting to be a pest. Having come to the department every two weeks for more than a year he was now so familiar with all of us that it was impossible to make him believe I was ever too busy to visit with him. But, I reflected, it was not his fault after all; the nurses had made a pet of him when he was in the hospital with his lung abscess and he had more or less had the run of the place ever since. I pushed back the papers on my desk and tried to keep the irritation out of my voice.

"All right. Let him in. But you stay here and move him out as soon as you can."

If I had not let Johnny in that morning it might have taken me several years to find out what I learned in the next fortnight. For the boy said gravely, "I don't think there's any use taking a picture of my chest today, doctor. You see I'm having a dry spell."

"And what, for heaven's sake, do you mean by a 'dry spell? Don't try to be funny, now. I'm busy."

"I'm not trying to be funny," replied Johnny aggrievedly. "It's just like I said. I'm having a dry spell."

And so indeed it turned out.

Eighteen months before, Johnny had come into the hospital to have his tonsils taken out. Everything went smoothly enough at the operation but the boy was so unlucky as to suck down into his chest a mixture of the blood and mucus which collected in his throat and soon afterward developed an abscess in the lower right lung. He hung between life and death for weeks. We did not have the sulfonamide drugs in those days and the doctors had a hard time saving his life. When he did get out of danger he was left with a chronic lung infection and even when he was well enough to leave the hospital he was coughing a great deal. Ever since he had gone on coughing and spitting, the nose and throat specialists still had him under treatment, and we were still X-raying his chest every two weeks. But now . . .

"What's this about having a 'dry spell'?" I asked again.

And Johnny patiently explained that of late he had noticed that part of the time he coughed and spat up stuff and part of the time he just coughed.

"If there's nothing there to spit out, I don't think there'll be anything there to see, either," he concluded with the restraint I have often noticed in children who are trying to explain something to an obtuse adult.

Johnny was right. The films of his chest which Miss Fairfax made that morning looked perfectly normal, but one made ten days later when his symptoms had reappeared showed the lung cloudy again. Then I realized that I might miss lung infection of this type if I happened to examine the patient for the first time during a period of improvement like Johnny's "dry spell." The long series of chest films which we made of this boy, ending only with his eventual complete recovery, confirmed this opinion and taught me many things about diseases of the lungs.

It may well have seemed to the early roentgenologists that the chest had been designed with them in mind, for here inside a bony framework is a pair of air-filled organs admirably adapted to photography. The X-rays penetrate the lungs readily but are held back by the heart and ribs and spine; therefore abnormalities of the lungs stand out in plain relief.

Tuberculosis

Tuberculosis is still one of the most serious diseases we see. In spite of a steadily falling death rate, this infection still kills more young adults than any other one ailment; in 1941 over sixty thousand Americans went to their graves because of it.

We have learned a lot about the diagnosis of tuberculosis of the lungs since the First World War. During the twenties, as the number of veterans breaking down increased and more and more hospitals had to be built for their care and it also became necessary to pay disability compensation and pensions to these men and their families, research men and tuberculosis specialists began to study great numbers of tuberculosis patients and their contacts; in this way they gradually learned how to recognize tuberculosis in its incipient stages before the patient complains of symptoms and to understand the ways in which it is spread through the community.

Now that we are at war again this knowledge has immediate practical value. It is obviously bad business to induct into military service a man with beginning tuberculosis: not only will he break down and become a public charge but he may also infect other men in his unit who in turn will break down and require long periods of treatment. This sort of endless chain of infection has already cost the United States over a billion dollars: that is what it has so far cost us to take care of the veterans of 1917 and 1918 who developed tuberculosis during or because of their military service.

Today every intelligent up-to-date physician knows that X-ray examination is our most reliable, single method of discovering early tuberculosis of the lungs and pneumonia. On good films no area of infection as large as one's fingertip should be missed. No such accuracy was attainable when I was in medical school.

My fellow students spent hours, first percussing out the studding in the walls of their rooms and then thumping each other's chests. We tried one another's stethoscopes and argued the merits of the various brands. We listened to our professors' description of vesicular, bronchial, and cavernous breathing and strove mightily to hear the same sounds in the dispensary cases we were permitted to examine as our skill increased. We were all equally anxious to discover the early lesions of tuberculosis, to spot pneumonia, but we were handicapped by unequal proficiency. Those endowed with a keen ear for tone and those with a talent for or training in music gradually made themselves good diagnosticians; the others did not. Lacking aptitude for recognizing changes in pitch and tone one cannot become an expert in this work. Without exception the best chest men I have known have been musicians or lovers of music. But anyone with good vision and the intelligence necessary to master the science of medicine can learn to see on X-ray films of the thorax very early and very small lesions in the lung. This is important because early diagnosis of tuberculosis and pneumonia means prompt treatment and prompt treatment of the right sort means early recovery.

It took time of course to wean established specialists from the stethoscope. They contended—and rightly—that they could make diagnoses as early as patients could be induced to come for examination. No one denied that—then or now. But these men possessed skill which ordinary doctors did not. Furthermore, for all their skill, certain complications escaped them which the roentgenologist saw at first glance.

When I was very new at X-ray work, there practiced in the town where I lived a very able chest specialist who felt great confidence in his ability to pick up lesions in the lung by physical examination. I respected this man for his unquestioned skill and for his professional integrity, and I wanted very badly to show him something on X-ray films of the chest which he could not find with his ears and stethoscope. I waited long and impatiently for my chance; over two years went by before it came. Then a patient entered our hospital who had a large cavity in the upper right lung which none of our staff picked up on physical examination but which was as plain as day on the X-ray film. Eagerly we baited a trap for Dr. P.; we called him in consultation and waited uneasily for what he had to say.

"Do you think she has a cavity?" asked one of us nervously when Dr. P. had finished his examination and left the patient's room.

He rolled his eyes as his habit was and started to say something. Then his shrewd gaze fell on me. I suppose my face gave me away. He looked at me sharply and grinned.

"So you've got something up your sleeve," he said slowly. "Trying to catch me up, eh? Well, I won't bite. I'm not sure whether she has a cavity or not. Now trot our your films and show me all about it."

No further admission could we wring out of him, but from then on I noticed that Dr. P. asked more and more often for chest films before committing himself.

It is unfortunate that more doctors were not as astute as he, at the time of the First World War, for we overlooked something of vital importance when we did not X-ray the draft army of 1917 and 1918. The armed forces today are more thoroughly examined than they were then. At first, to be sure, there was neither the equipment nor the personnel to X-ray all men called up for service but this deficiency was corrected as rapidly as possible and in 1942 no one was accepted for active duty in Army, Navy or Air Force who had not had chest films to prove that his lungs were free from tuberculosis and other infections. By following this policy, we can probably prevent the appearance of another huge crop of tuberculosis after this war; recruits who have the disease will be weeded out before they get into uniform and thus prevented from spreading infection among their comrades.

Age and Tuberculosis

One of the things not generally recognized about tuberculosis is the fact that it is not the same menace to all age groups. Thus, in infants it assumes a malignant form which is usually fatal in a few weeks or months but seldom causes serious illness in youngsters between five or six and thirteen or fourteen. In the late teens and the twenties it once more becomes an important hazard. After forty comparatively few persons develop tuberculosis except on a basis of a predisposing disease such as silicosis (dust disease of the lungs, or "miners' consumption"). To know this is to know which sections of the population must be examined in search of tuberculosis.

Babies pick up the germs easily. If great care is not taken when there is an open case of this infection in the household, disaster results. This was deeply impressed on me early in my career in medicine by the short sad story of Gwendolyn Brown.

Gwendolyn was a pretty mulatto baby, the only child of young intelligent colored parents. But her father had active tuberculosis and could not work, so that the family was very poor and had to live in one room. Besides this, all three of them slept in the same bed.

When she was seven weeks old Gwendolyn was brought into the clinic where I worked and a tuberculin skin test was done. She reacted strongly to it. Then we X-rayed her and found in her chest a great mass of swollen infected lymph glands. In eight months she was dead of tuberculosis. That taught me to keep a sharp eye on all small children in families where there are open cases of active tuberculosis.

Like many other infections, tuberculosis thrives best in the soil of poverty and carelessness. A few years ago, the New York City Health Department X-rayed 73,000 apparently healthy residents of that city. About 14,000 of them were high school pupils; 53,000 were relief clients; 2,500 were prisoners in jail; 3,642 were homeless men. Among the high school children only four cases of tuberculosis of the lungs were found for every thousand examined. Among the relief clients, whose average age was about thirty-six, a little over 4 per cent had active tuberculosis—ten times the percentage found among the high school students. The prisoners' average age was between thirty-eight and forty-three years, and 13 per cent of them were tuberculous. The homeless men were mostly over fifty and 16 per cent of them were suffering from tuberculosis.

This is an old story: poverty, crowding, ignorance, and carelessness breed disease.

Pneumonia

Pneumonia is another killer of first rank. In 1934 it killed 79.4 persons for every 100,000 in our population, and in 1935, 81.8. Since then, thanks largely to the sulfonamide drugs, the rate has fallen: in 1940 it was only 55 per 100,000. But now that we are again at war and millions of men are massed in military camps and multitudes of workers have been uprooted from their homes and shunted to defense areas where they live in congested unsanitary quarters, we must expect an upturn in both pneumonia and tuberculosis.

In pneumonia it is important to remember that chest films will frequently reveal cloudiness in the lungs a full day or more before examination with the stethoscope discloses anything definite. Time is of the essence in this infection no less than in contracts: early treatment means recovery, delay often means death.

Another significant point is that early pneumonia, especially if it is accompanied by pleurisy in the lower right chest, may cause so much pain in the abdomen that it is mistaken for appendicitis. In these cases, if pneumonia is not ruled out by X-ray examination, the patient may be put through an unnecessary and dangerous operation.

Ether Pneumonia

When I was studying medicine I heard a good deal about "ether pneumonia." It was one of the hazards that always had to be taken into account in advising surgery. As a result of research in which X-rays played an important role we now understand what this condition is and how it develops.

After a person has had an abdominal operation his diaphragm moves less than usual for several days, partly because of discomfort and partly as a reflex from the surgeon's handling of the abdominal organs. As a result the patient's lungs do not expand and contract as vigorously as normal, the amount of air moving in and out of them decreases and the mucous secretions in the bronchial tubes tend to stagnate. Presently when the air already in the air cells has been absorbed we have a condition in which various sized patches of lung contain no air at all. This state of affairs is called atelectasis.

Now airless lung tissue has been found to be readily infected; germs already present and those which manage to make their way into the lung through the bronchi or the blood stream find there excellent conditions for growth. And thus pneumonia—the so-called "ether pneumonia" of my student days, which may follow any other anesthetic or none at all.

Obviously to prevent the atelectasis is to prevent the pneumonia. Several methods of doing this are now in common use. One of them is the administration of carbon dioxide or a mixture of carbon dioxide and oxygen before the surgical patient is taken from the operating table. Either of these gases will stimulate his breathing and help clear out his bronchial tubes. Oftentimes this treatment is repeated periodically after the patient has gone back to his own room.

People who have been operated on are uncomfortable and tend to lie in one position most of the time. But nurses nowadays are instructed to see that they do not do this. They are moved frequently and this change of position also helps to prevent the development of atelectasis. As a result of all these things we hear much less of post-operative pneumonia than we did when I was a medical student.

Foreign Bodies in the Lung

In spite of Mrs. Montgomery's bizarre experience with the beauty pin, it is always dangerous to inhale a foreign body. Beans, peas, popcorn, peanuts and the like are worse than metal objects because, in the warm, wet interior of the lung, they swell up and produce more and more irritation and obstruction. There is ordinarily violent coughing soon after the thing goes down, and then shortness of breath. Later there may be a stormy illness due to infection. One of the worst lung abscesses I ever saw was in the lung of a man who ordered vegetable soup in a restaurant and was so startled when he found a bone in it that he inhaled the bone. During his subsequent illness the offending bone was removed and identified as a rabbit's vertebra—pronounced such not by a medical man but by an eminent zoologist who knew all about rabbits.

Two extremely dangerous things to have around the house where there is a baby are popcorn and peanuts. Both often produce lung abscess or pneumonia.

Naturally the symptoms vary according to the location of the foreign body. If a large solid object lodges in the windpipe (trachea) it will shut off all air at once and present a sudden major emergency, but a smaller object may be equally dangerous in the long run. For example, a foreign body stuck in a small bronchial tube may not obstruct the patient's breathing very much but will very likely produce a severe pneumonia.

The removal of these objects is essential and, thanks to Chevalier Jackson who invented the bronchoscope and taught physicians how to use it, this can be done safely in most cases. Of course it is necessary to know that a foreign body has been inhaled and where it has come to rest before one can take it out. If the child has been obliging enough to inhale a metal screw or the wheel off a toy train it is easy to localize it: the metallic body will throw a dense shadow on X-ray films of the chest and views made from several different angles will give a good idea of its exact location.

But peas and beans and popcorn and peanuts—the most dangerous of foreign bodies—do not cast shadows on X-ray films. So what then? Fortunately the X-ray man has the answer. You will remember I just had something to say about atelectasis developing when mucous collected in a bronchial tube interferes with the free movement of air into the lung. Well, the same sort of airlessness occurs when the obstruction is due to a pea or a bean or a kernel of popcorn. Let us follow the train of events.

A child inhales a bean. The bean sticks in the bronchial tube going to the lower lobe of the right lung, let us say. It is warm and wet down there and the bean soon swells, obstructing the bronchus more and more completely. No air can get past it, going or coming. In a short while the air in the air cells beyond the point of obstruction is absorbed and there ensues in that part of the lung a condition of airlessness (atelectasis). Then what happens?

Infection usually begins early. But even before that, changes occur which can be seen on the X-ray film. The lung, you must remember, is a light cellular organ like a honeycomb which is kept distended by the air within it; when the air goes the lung shrinks in volume. Now the thorax fits its contents pretty snugly and if some of the organs inside it change size there has to be a readjustment. This is what happens: the atelectatic portion of the lung being smaller than usual and the lower lobe of the right lung in this case having therefore shrunken, the diaphragm on that side rises and the heart is shifted toward the right. Seeing this on the fluoroscopic screen and on his X-ray films the roentgenologist would report that the offending foreign body is in the bronchus leading to the right lower lobe and that the bronchoscopist should go after it there.

I remember a striking case which occurred early in young Malvern's service in the children's ward and I know he will never forget it.

Late one winter day he called me on the house phone to say that a young couple had turned up with a baby who was having great difficulty in breathing.

"I can't see or feel anything in the kid's nose or throat and his heart seems to be all right. If I brought him downstairs I wonder if you and Dr. McDonald would look at him and give me a little advice?"

Naturally we did not object and presently Malvern appeared with the baby and two anxious looking young parents. While Miss Randolph unwrapped the patient the father told me that the child had never been ill before, that they lived more than fifty miles away, and that it had taken them several hours to drive down to the city.

The youngster proved to be a fine, robust, rosy-cheeked baby, eighteen months old, who was breathing noisily and with evident distress. He was using every muscle in the upper part of his body to suck air down into his lungs but he was not crying; he did not have wind enough for that.

McDonald listened to his chest while Miss Randolph and I got the fluoroscopic room ready. Then we took a look at him on the screen and found that it was even harder for him to get air out of his lungs than to get it in. When we finished the fluoroscopy, we set the film holder up in front of him and put the tube behind him; then, watching closely, we snapped several exposures while he was trying to inhale as well as exhale.

While Miss Randolph was developing the films we got the rest of the story from the parents. They said they first noticed the baby's difficulty in breathing shortly after noon.

"Where was he at the time?"

"He was playing on the davenport," replied the mother.

"Alone?"

"Yes. We have no other children."

"Do you remember what he was playing with?"

"An old rag doll." Then the mother added, with a flush, "He likes it better than any other toy he has."

It struck me at once that the youngster might have pulled off one of the shoe-button eyes often found on rag dolls but both his father and mother insisted that they knew both eyes were still where they belonged. And so I continued the cross-examination aided by McDonald, until at last the father recalled that they had had a guest the night before who had brought with him a sack of peanuts and had sat on the davenport most of the evening.

By this time Miss Randolph had the films developed and McDonald and Malvern and I all went into the darkroom to look at them. At a glance it was apparent that the baby was getting very little air into his lungs when he inhaled and still less out when he exhaled. This is what we call "expiratory dyspnoea"—that is to say, most of the air the patient is able to suck down into his chest stays there and, although his lungs are actually overdistended, he is partially asphyxiated. There was no displacement of the heart to either side and no elevation of the diaphragm, so I knew the two lungs were equally affected. McDonald agreed with me that the obstruction was in the windpipe (trachea) or the larynx and Malvern called a throat specialist at once.

Several of the nose and throat men tried to examine the baby during the evening and all failed; they were afraid to give him an anesthetic and he struggled so violently that they could not get a clear view of the interior of his larynx.

About two o'clock the next morning the child suddenly became worse. Malvern, routed out of bed by the nurses and thrown on his own resources until a staff man could reach the hospital, cut an opening in the windpipe below the larynx and put in a tube. Immediately the infant began to breathe more easily and to struggle less desperately for air; before the specialist arrived he had fallen asleep exhausted. But young Malvern kept watch beside him until morning for fear the tube would stop up.

This series of events proved that the point of obstruction was above the hole Malvern had cut in the trachea (windpipe) and before noon one of the throat men removed a tiny shred of peanut shell from between the baby's vocal cords, inside his larynx. The youngster slept practically all the rest of the day and by nightfall looked little the worse for his ordeal, but Malvern's face was gray and haggard for two days afterward. If I were a betting man I would wager that no one will ever bring a sack of peanuts near any child of his.

There are many other things, of course, that can be learned by X-ray examination of the chest. For example, the roentgenologist can tell you whether there is fluid between the lung and the chest wall (pleural effusion or empyema), whether the heart is enlarged and whether its shape is normal, whether the great artery leaving the heart (the aorta) is dilated forming an aneurysm, whether the patient with a goiter has a lobe of the enlarged thyroid gland sticking down into his thorax behind the upper part of his breastbone. There is also the very important matter of diagnosing tumors of the lung, of which more will be said later.

But just now I would like to make a few points about the two sorts of examination I have been discussing—fluoroscopy and films.

Fluoroscopy has its advantages. For instance one can watch the organs of the body in action and one can turn the patient around and study him from many different angles. Thus the heart can be examined and the rate and force of its beating noted; the movements of the diaphragm can be checked and measured.

But there are also disadvantages. Small abnormalities are easily missed on the screen by a man of average eyesight or little experience. Sometimes fluoroscopy consumes a good deal of time: when there is snow on the ground I have had to sit in the dark for twenty minutes after coming in from the street while my eyes accommodated themselves to the dim light of my workroom. Then the length of the fluoroscopic examination must not be great enough to overexpose the patient to X rays. And, perhaps most serious of all, there is no record of fluoroscopic findings except such notes as the examiner makes at the time: it then becomes a matter of his competence and the reliability of his memory.

Films, on the other hand, are permanent photographic records which can be preserved and studied as long or as often as desired and by many roentgenologists if need be. Small abnormalities can be seen on them more easily than on the screen, and furthermore they are admitted as evidence in courts of law.

The upshot of the whole matter is that fluoroscopy and films can no more be substituted for each other than the egg for the hen. Both are essential parts of an X-ray examination and neither can safely be omitted from most roentgenological studies.

Miniature Chest Films

One of the newer developments in chest work is the miniature film. It is almost as accurate as the full-sized film and much cheaper when large numbers of persons are examined.

The patient stands in front of an X-ray tube with a fluoroscopic screen hanging before him and the image on the screen is photographed with a camera having a very fine lens. The ensuing photograph may be either 4 by 5 inches or the common 35 millimeter miniature, depending on the type of equipment used.

The cost of the small films is approximately 10 per cent that of the full-size films (14 by 17 inches). The 4 by 5 pictures can be studied comfortably with a reading glass; the smaller miniatures are enlarged in a projector and thrown on a screen of the sort used for kodachrome slides and home-made movies. Errors in interpretation, compared with the large films in ordinary use, do not run over 2 per cent on the average.

These small films are easy to handle and easy to store. In the old days the filing of X-ray films was a real problem. They were astonishingly heavy, they took up an even more astonishing amount of space, and after the Cleveland Clinic disaster of 1929 we realized that they might cause explosions and fires. Some hospitals built large storage vaults underground, others constructed filing space on the roof. We were afraid to throw films away for fear they would be needed later on in court or in diagnosis of subsequent illnesses, and so we groaned and sweated over our ever-growing and ever more bulky X-ray files. As soon as the noninflammable safety film became available we switched to it at once, but that did not solve the filing problem. It remained a bugbear until the miniature camera craze of the thirty's set many of us copying our large films in small convenient sizes and until the fluorographic method just described supplied the more fortunate among us with small originals.

There are actually only two disadvantages to this new technique for chest examination. One is the necessity in doubtful cases of re-examining the patient with large films. However, this wastes comparatively little time and, as it does not often occur, it adds relatively little to the cost of the examination. The major disadvantage is the high price of the equipment. One must have a special fluoroscopic screen (made with zinc sulphide) which shines with extremely brilliant blue-violet light, a heavy-duty X-ray tube which will deliver a large current (at least 400 milliamperes), a timer which will insure accurate and very quick exposures, and a camera equipped with a fast lens that will give sharp negatives of fine detail.

Not many hospitals can afford to scrap their old machinery and sink a great deal of money in this new apparatus. Although all our mouths water for it like a small boy's for candy, it will take some years and a good deal of sales-talk to get this equipment. But we do not despair because of this. I remember one of the finest roentgenologists this country has ever had telling me that in his first department the darkroom was two stories above the workrooms. And I also remember my own experience during the First World War when, in an isolated lumbering hamlet in the Far West, a roaring spitting sparking static machine was my daily cross for months on end. And yet I got usable plates of my patients. Our need is not so much for better apparatus as for more wisdom in the use of what we have and for men with a competence to match the efficiency of the equipment now available.

CHAPTER VI

The Roentgenologist Examines the Head

SKULL FRACTURES

WHEN I first began to study X-ray work I was one of a group taking a course of instruction from a well-known roentgenologist. He was showing us the different methods of examining for skull fracture when it struck me that if the patient was not in a bad way when the examination began he was sure to be so by the time it was finished. I think we were all horrified by the position advised when one suspected that the bones in the base of the skull had been injured: the victim lay on his back on a table with his head hanging over the end and his neck stretched and bent backward until the top of his head rested on the casette on a sort of shelf projecting from the table several inches below the level of its top.

"I hope to God I never have to have the base of my skull X-rayed," muttered the man sitting next to me and I agreed.

All through my early years as a roentgenologist I was distressed by the frequent requests to examine patients for skull fracture as soon as they were admitted to the hospital; many of them were unconscious, many of them were in shock, and I was always afraid that the maneuvering we did and the positions we had to get them into did more harm than the results of the examination could justify. It has been reassuring to see that this custom has little by little declined; nowadays the man suspected of having a skull injury is not usually rushed into the X-ray department the first thing. More often he is first treated for shock or his spinal canal tapped and some fluid removed. If there is blood in this fluid there has been definite injury to either skull or brain or both, and the doctor in charge can then plan his treatment and time the X-ray examination to cause the least possible damage.

Finally, modern shockproof apparatus without dangling wires and exposed electrical connections makes it possible to get all the films needed on these cases with a minimum of movement. The patient need no longer be an acrobat for us to get satisfactory pictures of his head.

One of the things experience taught me is that other conditions may be mistaken for skull fracture. Several years ago I got a hurry-up call to examine a woman who had been knocked down by a truck, taken first to the police station and then to the hospital. When I hurried into the X-ray room I found her there, lying on a stretcher unconscious and breathing noisily.

Miss Abbott scuttled into the darkroom for casettes and films and I set about moving the cumbersome old-fashioned tube stand into position so that we could get our exposures without moving the injured woman more than we could help. As I did so something about her color struck me as odd. I left off struggling with the apparatus and pried her mouth open. Her tongue had rolled so far back that I could see very little but when I felt around in her throat my finger encountered something hard. In another moment I was scratching out teeth and bits of dental plate onto the floor.

Miss Abbott, returning with her casettes, stared at me in amazement.

"Bring me a towel," I said. "And get some gauze and hold this woman's tongue out of my way."

As soon as we had raked out all the teeth and bits of composition material we could feel, we yanked the patient's tongue briskly a few times, gave her a respiratory stimulant, and soon had the satisfaction of seeing her gradually lose her ghastly bluish-red color and begin to breathe naturally. Presently she opened her eyes and asked where she was and what had happened. In less than an hour we had X-rayed her chest, to make sure she had not inhaled any of her teeth, and sent her home considerably bruised but otherwise undamaged except for loss of her dental plates.

Since then I have never concluded that a patient has a fractured skull until I first make sure that he is not asphyxiating himself with his own tongue or his dentures.

Brain Tumors

Although it has by no means supplanted the older study of the nervous reflexes and the interior of the eyeball, X-ray examination plays a fairly important role in the diagnosis of brain tumors. All intracranial growths are dangerous, whether benign or malignant, because there is not room inside the hard unyielding skull for both the brain and a growing tumor. Besides, all possibility of operating successfully depends on early and accurate diagnosis.

Sometimes plain films of the head tell us a good deal. For instance, in children the bones of whose skulls have not yet grown firmly together, the clefts between these bones may be greatly widened by the increased intracranial pressure caused by brain tumor. Another change sometimes seen, particularly in young people, is a spotty appearance of the bones of the skull resembling impressions made by finger tips in putty.

There are also tumors which lie so near the surface of the brain and so close to the skull as to produce localized changes in the adjacent bone. In the floor of the skull there is a little niche which houses the pituitary gland; it is called the *sella turcica* (Turkish saddle) because in profile it looks somewhat like a saddle with high horn and cantle. Several types of brain tumor cause visible changes in the sella: its floor may be depressed or destroyed, its walls may be thinned out or broken down. Fortunately the tumors which produce these changes can in some cases be removed so successfully that the patient returns to normal.

Two structures inside the head which commonly calcify as we grow older are the pineal gland and a cluster of blood vessels known as the choroid plexus. Brain tumors of considerable size are likely to displace one or both of them. If they can then be seen on the X-ray films in an abnormal position we have a clue to the location of the growth.

There is another fairly common intracranial tumor which can sometimes be seen by reason of calcium deposits; this is the Rathke pouch tumor, which develops near the sella. It is cystic and not infrequently on good films one can see thin lines of calcification in its walls. Every roentgenologist is on the watch for it because it can often be removed successfully. I remember that the first person I ever saw who had had an intracranial tumor removed and subsequently recovered completely was a boy with a Rathke pouch tumor; he used to come into the hospital where I took my graduate training in radiology for periodical checkup and we all took great interest in watching him grow up into a normal young man. If he had not had the correct diagnosis and been operated on by a master surgeon he would have died while still a child.

Encephalography and Ventriculography

In recent years a somewhat spectacular method of examining the brain with X rays has come into use. It consists of injecting air into the spinal canal and/or the interior of the brain itself, before films are made.

There is a space around the spinal cord, inside the spinal canal, and another space around the brain, between it and the skull. These spaces communicate with each other through narrow tortuous pathways. In addition, there are within the brain small cavities known as the ventricles. It is possible to inject air into this system of communicating spaces.

We do this in one of two ways: by putting a needle into the lower part of the spinal canal, withdrawing some of the spinal fluid and replacing it with air, or by removing a small piece of the skull, inserting a needle directly through the brain into one of the ventricles, removing part of the fluid inside this cavity and replacing it with air. The first method is called encephalography, the second ventriculography. Each sounds worse than it really is.

The patient suffers little actual pain during either procedure but he often has headache, nausea, and other minor discomforts for a day or two afterward. Properly done, these examinations are not dangerous and they are very valuable in many cases.

A brain tumor of any considerable size will cause changes in the size and/or shape of the ventricles; those which grow in or near the base of the brain are also likely to obstruct the intricate passageways between the ventricles and the space around the brain and spinal cord.

One feature about both these methods of study which often strikes people as odd but is actually very simple is the necessity of keeping the patient upright during the whole performance. Since air is lighter than fluid and consequently rises above fluid, it will collect inside the skull only if the patient is not allowed to lie down. I have always thought that probably the thing about encephalography and ventriculography which really disturbs the patient most of all is this compulsion to sit up when he feels ill.

X-RAY EXAMINATION OF THE TEETH

One of the best known types of X-ray examination is the making of dental films. Even this apparently simple undertaking is not without its perils for the roentgenologist: I have more than once been bitten in the process and people with halitosis are always disagreeable patients.

We used to be told that a clean tooth never decays. Most of us have long since discovered that this is not true, but it is not always so well understood that the converse is not true either. I first had this impressed on me in a tuberculosis sanatorium where I worked. A new patient came in—an elderly man of Lithuanian birth who had never owned a toothbrush and whose mouth was filthy. After he had been studied and a course of treatment for his tuberculosis planned, our consulting dentist undertook to clean up his mouth. I shall never forget the astonishment with which I looked into the man's mouth after this operation had been completed and saw a beautiful set of teeth without a single cavity and with but one gap where a cuspid had been knocked out in a fight thirty years before.

Nearly all of us have endured the searching of the dentist's probe but there are cavities which this instrument misses, unlikely as that seems to the patient—chiefly those between closely spaced teeth. These show up plainly on X-ray films.

Then there are teeth which never make their way through the gums; these unerupted teeth, as they are called, are easily found with X rays. So are impacted teeth—those which are trying to come in at an impossible angle or in a place where there is no room for them, and which often produce strange symptoms. I remember a young woman in the hamlet where I first practiced who had a wry neck for years because of an impacted wisdom tooth; when the offender was taken out she promptly ceased looking over her left shoulder.

The double teeth (bicuspids and molars) have multiple roots which curve toward the tips. Because of this parts of these roots frequently break off and remain behind in the jaw when the teeth are pulled. Years later an X-ray film may reveal them still in the bone, sometimes infected besides and the source of much trouble. Many but by no means all teeth infected at the roots (apical abscesses) can be diagnosed on dental films; I would not advise anyone to go to a dentist who depends entirely on X-ray examination to find infected teeth.

Foreign Bodies in the Eye

One of the less well known uses of X rays is the localization of foreign bodies in the eye. Every year during the hunting season several men and boys are brought in for us to find out whether any of the shot peppered over their faces has penetrated an eyeball. The examination is rather difficult, requiring both special apparatus and triangulation from the films, but it is accurate for the most part. X-ray laboratories do not usually have many cases of this sort, however, so most roentgenologists groan a little over the plotting on scale paper and the calculations.

Perhaps the most interesting experience I ever had in this field was with a miner who was sent to me by an oculist in town with the request that I find out whether there was a bit of rock in his right eye. I asked the patient whether he had ever been X-rayed before and he said no. I then got him on the table with his head in the localizing apparatus and made the necessary films. The exposures required are long and since one of my films was not entirely satisfactory I had to make it over, but I had calculated my dose carefully and knew I had kept within the limits of safety. I studied the films painstakingly and reported to the eye specialist that I could see no foreign body inside the orbit.

Imagine my dismay a few weeks later to have him call me up and say that he had just seen the patient who vowed that he was going to sue me because his hair had come out. Shortly afterward I heard from the man's lawyer. It was quite true: the patient had lost every hair on the right side of his head and he was very angry and quite determined to bring suit against me.

The oculist and I then made some inquiries and found that the man had gone to three eye specialists on three successive days, without telling any of them that he had already consulted someone else; each oculist in turn had sent him to an X-ray laboratory for examination. It was my misfortune to be the last on the list—the one who gave the final shot of X rays that ruined his hair.

To my own attorney I pointed out that I had asked the patient, before examining him, whether he had been X-rayed previously and that he had lied to me. I produced the card from my files on which I had written down the patient's name, age, address, complaint, type of examination done, fee charged, and his own statement that this was his first X-ray examination. But the lawyer was still unhappy. He pawed through my books on X-ray reactions and muttered to himself and finally went away greatly perturbed.

But the next morning he came back with the bright idea that he should get the case postponed to the autumn term of court and that meantime the man's hair might come in again. He did, and it did, and the malpractice suit was dropped.

CHAPTER VII

The Roentgenologist Studies the Digestive System

Examination of the Gall Bladder

THE digestive system is a long tube which extends from the mouth to the rectum. Through it food moves by reason of the waves of contraction which travel along its muscular walls; in it digestion takes place by reason of substances secreted by its lining and by various glands which empty into it. The liver is one of these glands. It manufactures a material known as bile which is necessary in digestion, especially of fats. Bile oozes out of the liver cells into the bile ducts and along them into the gall bladder where it remains until it is required to help digest the next meal.

By taking advantage of this sequence it becomes possible to X-ray the gall bladder. The patient drinks or has injected into his veins a certain harmless dye which is absorbed from the digestive tract and carried to the liver. The liver in turn slowly excretes it in the bile and as the bile accumulates in the gall bladder the dye also is concentrated there.

When we make X-ray photographs of the normal gall bladder we see an oval shadow about the size of a small egg which disappears or shrinks greatly after a meal containing fatty food. If the shadow does neither something is wrong. Perhaps the gall bladder is infected, perhaps it contains a tumor or gallstones. If there is difficulty in making sure exactly what the trouble is, McDonald can probably help settle the question. By working together, the laboratory man, the practicing physician, and the roentgenologist can almost always reach the correct diagnosis.

There are still people who think they can take a drug that will dissolve gallstones. Early in my medical career I learned how useless it is to tell these people that it would be as easy to dissolve them from around the stones as to dissolve the gallstones without doing havoc to the surrounding tissues. And so, sometime ago, when I encountered a particularly pig-headed patient I tried another tack.

Mr. X. was sent in by a physician, as I am sure Miss Randolph remembers, shortly after she came to work with us. He complained about the taste of the dye he was given, he objected to being X-rayed by a woman technician, he either could not or would not hold his breath as she asked him to do while the exposures were made. But in the face of these difficulties, Miss Randolph brought me several excellent films on which his gall bladder persisted in spite of fatty food. The shadow was definitely mottled, indicating stones, but Mr. X. refused to believe either his physician or me when we explained the condition to him and made no secret of his determination not to have an operation.

After this we saw nothing of him for a year or so, then one day he came in, this time referred by another doctor but for the same examination. The stones were larger and plainer than before; even Mrs. X., who appeared if possible more stupid than her husband, admitted she could see them. But once more nothing the attending physician or I could say would convince the patient that we knew what we were talking about. He told us both that he had some medicine which he took at intervals which dissolved the stones easily; "only," he added, "they keep comin' back."

After this Mr. and Mrs. X. appeared periodically in the department, sometimes referred by one doctor and sometimes by another. At each examination the gallstones were larger and more distinct and always Mr. X. reiterated his explanation; it was a simple matter to get rid of the stones, the only problem was to find a way to keep them from forming again.

Since I was so obstinate as not to believe this, he finally determined to prove to me that I was wrong. He dosed himself with his medicine, collected the numerous small hard objects which subsequently appeared in his stool, and brought them into the laboratory in a bucket for me to see. Knowing that it would be useless to tell him that they were soapstones formed in the intestine by the reaction between the medicine and the intestinal contents, I suggested that final proof of his thesis would be films of the gall bladder made then and there showing no stone shadows. As soon as I made it clear that this examination would cost him nothing, Mr. X. was quite willing to be X-rayed again.

In my lifetime thus far there have been few moments of sweeter triumph than the one in which I set the wet film, fresh from the darkroom, in the view box at the end of the long series made on previous visits and pointed out to Mr. X. not only that there were still stones in his gall bladder but that even their number and shape remained unchanged. But as Mr. and Mrs. X. went away down the corridor there was something in the look of their retreating backs which told me that, though I might have proved my point, I had not convinced either of them. Out-foxed they certainly were, but of the same opinion still.

Examination of the Stomach and Intestines

Wilhelm Konrad Roentgen discovered X rays in the autumn of 1895. Less than six months later a scientist in Berlin was photographing lead compounds in the stomachs of guinea pigs and in the same year the American scholar, Dr. W. B. Cannon, began using capsules filled with bismuth in the study of the animal stomach. In 1898 Dr. Cannon first used bismuth mixed with food in the X-ray examination of the human stomach, and from that day on the study of the digestive tract has been one of the most interesting and profitable fields for X rays.

For a good while bismuth was the only material used for this work, but at last it was found that some people absorbed enough of it to be poisoned, and so barium was substituted. Barium is safe because it can neither be digested nor absorbed; it leaves the body in precisely the same chemical state as when it was swallowed. It has no real taste, it feels like chalk in one's mouth.

Usually it is mixed with some fluid because liquid will fill the stomach and bowel better than any dry substance. The first X-ray laboratory I worked in used a revolting combination of barium stirred into thin apple sauce. Buttermilk was a favorite with roentgenologists for a long while. More recently we have come to use simply barium and water beaten together in a mixer, although prepared barium meals can be had disguised with chocolate and other flavors.

In one respect most barium drinks resemble cod liver oil: people think they are nasty because other people say they are.

Esophagus

The tube between the mouth and the stomach, known as the esophagus, is fortunately rather immune to disease. A few people are born with a sort of pouch off to one side of this passage (a diverticulum) in which food collects instead of going down to the stomach, and some children are still unlucky enough to swallow lye by mistake and develop an obstruction, while an occasional adult has cancer of the esophagus. There are, too, some persons who have varicose veins in the wall of this tube.

All these conditions can be seen with X rays. The esophagus lies back of the heart and in front of the spine, and by studying the patient's thorax obliquely one can see it clearly when it is filled with barium mixture. In this work we usually use a thick barium paste which will not run down into the stomach too rapidly. Whatever difficulty there is in examining the esophagus is likely to be in slowing up the downward movement of the barium mixture. I remember an experience I once had in this connection.

The patient was an elderly woman who had had three massive hemorrhages from the stomach at intervals of several years but who, aside from this, was in good health. The bleeding when it came was alarming and she had gone to many doctors without getting relief although many diagnoses had been made. It was clear to us all that she could not have a cancer, otherwise she would have been dead long since. It was equally certain that she had no obstruction anywhere along the digestive tract and no symptoms of ulcer and nothing to suggest a lesion in the intestine. But when she was sent into the department for X-ray examination she had but recently recovered from a hemorrhage and was both mystified and uneasy about herself.

Miss Randolph prepared some stiff barium paste and we began our regular fluoroscopic study. But thick as it was, the barium mixture ran through the esophagus too fast for satisfactory examination. The patient was short and stout, she simply could not twist around into the positions I suggested. (Miss Randolph and I afterward referred to her as the unbendable woman.") We finally wound up with her lying half on her face on the fluoroscopic table, with the table tilted so sharply that her head was much lower than her feet, and kept from sliding off onto the floor only by the united efforts of Miss Abbott and Miss Fairfax. However, we got a good look at her esophagus and made some good films. She proved to have dilated veins in the lower end of the tube, near its entrance into the stomach. Although treatment of this condition is not very satisfactory, she was so delighted to know what was wrong and to have her dread of cancer allayed that she held no grudge against us. But when she finally departed, I heard the technicians say to each other that they hoped the next esophagus case would be a little more flexible.

Peptic Ulcer

More often we are asked to examine the stomach or the first portion of the small intestine (the duodenum) for ulcer.

A peptic ulcer consists of a pocket eaten partly through the wall of the intestine or stomach, starting from the inside. Into this tiny crevice our thin barium mixture runs and there some of it sticks; that little speck (known in X-ray jargon as a "fleck") is one of the many things the roentgenologist watches for. Often it is no larger than a grain of wheat and unless he is skillful and thorough the examiner may miss it altogether.

But there are other things which must be looked for in the ulcer case. The irritation caused by the disease results in overactivity of the gastric muscles; they contract more vigorously and oftener than normal and the waves of contraction follow each other more closely than usual. Again, in many patients, this irritation causes the puckering string muscle between the stomach and the duodenum (the pylorus) to close tightly in a spasm and delay the emptying of the stomach. This obstruction may become chronic and so high-grade that material remains in the stomach for three or four days after it is eaten.

In large ulcers of long standing the stomach wall may become so stiff and thick that the waves of contraction (peristalsis) skip that particular area entirely.

These therefore are the things the roentgenologist looks for when stomach ulcer is suspected: (1) a tiny pocket or niche in which a little blob of barium sticks; (2) overactivity of the gastric muscles (hyper-peristalsis); (3) spasm of the outlet of the stomach (pylorus), with delay in emptying. None of them is easy to spot in mild or early cases; some of them may be absent in any case, however advanced. An amateur is likely to miss most of them.

When the ulcer is in the duodenum (the first twelve inches of the small intestine), the pocket or niche and the deformity it produces are seen in the small bowel and not in the stomach, but there is the same muscular over-activity as in gastric ulcer, while the spasm and delay at the pylorus (the gateway between the stomach and intestine) are apt to be even greater.

It may not be amiss to say something here about the background of ulcer. Medical men no longer regard ulcer as a purely physical disorder. On the contrary we recognize that its origin is largely in the field of the emotions. The typical ulcer patient is a man under forty-five, probably tall and rather lean, a driver filled with energy and ambition. His digestive troubles are not constant but come on in attacks, usually following a period of anxiety, fatigue, or emotional strain. If this psychological background persists without change, he will go on having recurrent bouts with his ulcer.

It is for this reason that fewer and fewer operations are done for uncomplicated ulcer. When conditions are ripe, the disease recurs—operation or no operation. For instance I know a surgeon whose ulcer flares up whenever a difficult surgical task confronts him or he is worried over a patient. I have another friend whose ulcer lays him by the heels whenever his love affairs get him down. And every ulcer patient knows the danger into which anxiety and overwork precipitate him. The day is probably at hand when a psychiatrist will be called in consultation before any course of treatment is planned for this type of case.

Cancer

Cancer of the stomach produces thickening of the wall rather than a niche or pocket. On the fluoroscopic screen and on films this appears as what we call a "filling defect." That is, the outline or silhouette of the stomach is irregular and the cavity of the interior is smaller than normal.

The stiffening and thickening of the wall prevent the waves of muscular contraction from running normally over the stomach; sometimes the barium simply pours through into the intestine as though it were going down a funnel.

The first case of this sort I ever encountered I shall never forget. It was early in my career as a physician and before I had had any special training in roentgenology. The patient was a middle-aged man who came in from an oil field acutely ill but who insisted that he had always been perfectly well until a week before. After a day or two of observation convinced me that he was in a very serious condition, I essayed to examine his stomach with the crude X-ray equipment available. But I found that I could not keep enough barium in his stomach to get a satisfactory plate. It streamed through the pylorus into the intestine in a perfect maelstrom, telling me nothing except that there was no obstruction up to that point. After many struggles, I found that I could tie the patient's feet to the foot of the table, then tilt the table sharply, give him a glass of barium, and make exposures while he was in the act of drinking the mixture in this headlong forty-five-degree position. By this device we made a diagnosis of diffuse cancer involving the entire wall of the stomach—a diagnosis which a surgeon soon confirmed although he found the condition inoperable.

If the growth is near the opening of the stomach (the pylorus) it often causes partial obstruction and the barium therefore passes into the duodenum more slowly than usual. Very small early cancers may produce this symptom by irritating the pyloric muscle so that it goes into a spasm.

The great difficulty in diagnosing gastric cancer lies in the fact that it seldom causes symptoms until fairly well advanced; therefore many of the patients we see are by that time in hopeless condition.

Happily cancer of the small intestine is rare. But malignant tumors frequently occur in the large bowel (colon). Unfortunately they too are slow to cause symptoms which attract the patient's attention, but since they are often not highly malignant they can in many instances be cured by operation.

Cancer in the cecum (the first part of the large bowel, in the lower right side of the abdomen) may give itself away before other symptoms develop by an anemia due to slow persistent bleeding from the tumor. I remember a middle-aged woman I once examined who surprised me almost as much as she did herself. She was apparently in good health, but, having been sold on the idea of an annual physical checkup, she decided to have an X-ray examination of her digestive system in addition to a physical examination by her family physician. When the barium meal reached the cecum I saw that the bowel was not filling well: it was ragged in outline and did not fill uniformly.

I reported this to her doctor. He sent her to McDonald at once. McDonald did a blood count and found an anemia; he examined the stool and found blood in it. Less than a week later Dr. Douglas operated, found an early cancer, took out the first part of the colon, cancer and all, and spliced the remaining intestine together. The woman made an uneventful recovery and seven years later, when I last heard of her, was alive and well.

A year or two ago we had another interesting experience with cancer of the large bowel. This patient also was a middle-aged woman in apparently good health except for a little bleeding now and again from the rectum. Instead of dismissing this as probably due to hemorrhoids or constipation she went to a doctor who, finding nothing on physical examination, referred her for X-ray study. We in turn gave her a barium enema without difficulty and without seeing anything wrong on the fluoroscopic screen. But the next morning, on the dry films, I thought I could make out a little raggedness of outline along the lower part of the colon just above the rectum. So I requested a re-examination.

This time I watched the lower bowel very closely and injected the barium solution slowly and carefully. By twisting the patient from side to side I was finally able to see a small but definite lesion on the screen and to get some good films of it. Within a week she was operated on; a small cancer was found barely starting to invade the muscular wall of the bowel from the mucous lining. A short section of the intestine was removed, the remaining bowel was spliced together, and the patient made a prompt recovery. There is every prospect that she was permanently cured.

Tuberculosis of the Bowel

Tuberculosis too attacks the large bowel and sometimes it is very hard to differentiate from cancer. Because of this very thing another patient remains vivid in my memory.

She was brought into the hospital painfully emaciated, bleeding from the intestine, and quite out of her mind. Because of her mental confusion it was hard to do the usual examinations; she flatly refused to swallow any barium mixture we offered her and after wasting two days in vain attempts to reason with her we decided to do a barium enema at once.

Although she was not strong enough to prevent our doing this, she put up so much fight that I had to call in not only Miss Randolph, Miss Abbott, and Miss Fairfax, but also old Amos and two nurses from the floor. When we finished I was not sure whether there was more barium inside the patient or on us and the walls and floor. But we had got some excellent films and I had had a good look on the fluoroscopic screen. Studying these findings carefully I concluded that the condition was probably a cancer of the first part of the colon (cecum) but that it could very likely be removed surgically.

Operation was done promptly; it showed not cancer but a chronic tuberculosis involving only a comparatively small part of the large bowel. This area was resected and the remaining intestine sewed together again. In two weeks the patient went home much improved physically.

About a year afterward a well dressed, nice looking woman came into the department one afternoon and asked for me. When she saw that I did not recognize her she smiled and said, "I'm not surprised that you don't remember me. I've changed a great deal since last fall when I was operated on for tuberculosis."

Not only had she recovered her health and gained almost sixty pounds, but her mental state had cleared up as her general health improved. (N. B. This is not to be regarded as a suggestion that all psychotic patients have disease of the large bowel and should have a piece of it taken out.)

Colitis

Another common disease of the large intestine—colitis—was so fashionable a few years ago that in many cities there were flourishing clinics where colonic flushings and other insults were inflicted on the misbehaving bowel, all to the profit of the operators and the detriment of the patients.

Every doctor knows the symptoms of colitis and every X-ray man knows what the bowel looks like in these cases—constricted, narrow, smoothly outlined, without the normal muscular markings. But unlike persons who have tuberculosis or cancer of the intestines, these patients are not helped by surgery or by repeated irrigations of the colon. Ordinary garden-variety colitis is a disease whose causes lie in the emotions and psychological reactions of the individual and whose cure must be sought in these realms and not in the operating room or the quack colonic flushing clinic. As with peptic ulcer the day may not be far off when a psychiatrist will be called in consultation before any physician undertakes to treat colitis.

Infection of the large bowel with the germs of dysentery is quite a different matter and a very serious one, but no good doctor will confuse these conditions, especially if he remembers to have the laboratory do that simple, important but often neglected test—the examination of the patient's stool for blood and pus.

CHAPTER VIII

The Roentgenologist Studies the Urinary System

ONCE when I was a brand new country doctor I was called to see a young fellow who had wakened suddenly during the night with a pain in the right side of his abdomen. When I first walked into his room my eye caught the drawn look about his mouth and the little drops of moisture on his upper lip which spell suffering. Remembering my professor in practice of medicine I went over the patient's chest first of all, to make sure that he did not have a pneumonia in his right lower lung which was telegraphing pain into his abdomen. Finding nothing there, I next examined his belly. I saw him flinch when I pushed my fingers into the abdominal wall and felt the muscles tauten and turn hard under my exploring finger tips. Meantime he explained that he felt "half sick to the stomach."

One half of my brain said to me, "What a break when you're new in the community! Here's a healthy young chap with a clear-cut appendicitis. You couldn't find a better surgical risk. Take him into town to the hospital and operate on him. He'll get along all right and all his friends and relatives will think you're a fine surgeon. Don't hesitate! People like a doctor who tells them what's wrong right away."

But another voice in my mind spoke up before I could open my mouth. "Careful there! Don't go off halfcocked.

This might not be appendicitis, you know. You don't want to make a mistake the very first thing."

So I went out to my car and brought in the microscope I always carried on the seat beside me, stuck the patient's ear and got a drop of blood. At the kitchen table, facing the window to get the best light, I counted the tiny cells under the 'scope—the white blood cells which rush to the body's defense against infection.

The result was 8,300—a figure which told me practically nothing. It is true that 8,300 white blood cells per cubic millimeter of blood are a little more than normal, but not much more. This neither proved nor disproved the presence of an infection. I washed off the slide and put the microscope back in its case, no wiser than before. I had a strong impulse to say to the boy's father and mother, "Look here, your son's got appendicitis. We must take him into the hospital right away," but an even stronger impulse to hedge.

And hedge I finally did. I said I would come back later in the day and went away, leaving some tablets to be taken if the pain got worse.

That afternoon an older doctor whom I knew dropped in to see me. I had just been speaking over the phone to my patient's mother, who said he was about the same, and now I called her back to ask whether I might bring out my friend in consultation. The relief in her voice assured me that nothing would please her more, and when I led my solid middle-aged companion into the sickroom an hour later and saw the expression on her face I learned something I have never forgotten—it is better to suggest consultation yourself than to wait for the patient's family to ask for it

My friend examined the young man much as I had done, he asked many of the same questions, and he waited until I did another blood count before he gave his opinion.

"U-m-m. I see. Blood count hasn't changed much, has it?

Why not get a specimen of urine and look at it. I notice that the patient says his pain goes through into his back and down a little toward the groin. Perhaps his appendicitis is really a stone in the ureter."

And so it was. The urine was loaded with red blood cells, we gave the young man a few large doses of morphine and atropine to relax the muscle spasm and relieve his pain, and the next day he passed a tiny stone no larger than a grain of rice and dramatically lost all his symptoms.

Urinary Stones

Stones form in the bladder, in the kidneys, and in the ureters (the long narrow tubes leading from the kidneys to the bladder). Judging from biographies and memoirs, bladder calculi—then called simply "the stone"—must have been much more common in the seventeenth and eighteenth centuries than they are now. But they are still by no means rare, while kidney and ureteral stones are frequent.

Three-fourths of all calculi in the bladder and 95 per cent of those in the kidney and ureter will cast visible shadows on X-ray films—despite the fact that many of them are not larger than a grain of wheat. Hence failure to find such a shadow on well-made films is strong presumptive evidence against the existence of stone. I had a queer experience while I was still a tyro in roentgenology which impressed this upon me.

The hospital in which I was working at the time had the best X-ray equipment in town and one afternoon a man came in with a note from a surgeon I knew explaining that the patient's symptoms suggested bladder stone and requesting me to make plates of his pelvis. While I was getting the machine set up I quizzed the man a bit about his history. Afterward I remembered having wondered how anyone who had suffered so much and lost so much blood could look so well nourished and red in the face, but at the moment it did not occur to me that the man might be malingering.

However, when I got my films out of the hypo and found nothing abnormal on them, I asked still more questions and then suggested to the patient that he allow me to inject air into his bladder, pointing out that any stone—however small or incapable of casing a shadow itself—would then be sharply outlined against the background of the hollow air-filled organ. In surly fashion he refused. Undaunted, I argued the matter with him, giving assurance that the procedure would be practically painless. With increasing vehemence he again refused.

Finally, having become suspicious, I asked him to void in my presence, explaining that by examining the urine I might get some idea whether he had a large or a small stone. This, he said curtly, he could not do. Since I could think of no other type of examination which did not require the patient's co-operation I let him go without doing anything more and reported to the surgeon that I could neither confirm nor disprove the tentative diagnosis of bladder stone.

But the man continued to complain, to insist that he was in constant pain, and to demand that something be done for him. At last the surgeon sent him to a genitourinary specialist who reported, after examination, that when he passed the metallic instrument called a "sound" into the patient's bladder he felt a solid object there. In the end the surgeon unwillingly operated and, when he opened the bladder, found it perfectly normal.

During his convalescence the malingerer explained himself. He had worked for a certain company for twenty years and during this whole time had paid monthly dues to a sick-benefit insurance fund, but had never once required more than first aid or minor medical care. It seemed to him that he had not had his due and that he never would have unless he developed some serious ailment. Having once had a friend who had had a stone in the bladder, he decided he would have one too and bluffed his way into the surgery with that diagnosis. But before he left the hospital he acknowledged that he had made a poor choice.

Since then I have been chary about admitting the presence of any urinary stone I cannot see on good X-ray films.

Few things cause more pain than a little stone inching its way down along the ureter from the kidney toward the bladder, but sometimes a kidney will be almost entirely replaced by stone with very little suffering. I once saw a middle-aged woman whose right kidney had been converted into a mass of mineral deposits the size of my fist but who flatly refused to have it removed, on the ground that, although it was practically functionless, it did not bother her enough to justify the expense of an operation. For a long time I kept her films to show our succession of internes how much could happen to a kidney without affecting the patient's general health seriously.

Pyelography

Until some fifteen years ago, when we wished to make a real X-ray study of the upper urinary tract, it was necessary to put the instrument known as the cystoscope into the bladder—this in itself being no small undertaking—and then push up each ureter a fine tube through which we could inject into the kidney a liquid which would cast a visible shadow on the X-ray film. This procedure was difficult enough to require a specialist and painful enough to give the patient a bad half day, to say nothing of being time consuming. But since it gave accurate results in most cases, it was much used.

Then, toward the end of the twenty's, a dye was found which we can safely introduce into the blood stream and which then rapidly collects in the kidneys and bladder. This examination causes no pain and takes only a short while; therefore it is now widely used particularly in nervous patients and children. It has the additional merit of demanding much less technical skill than the older method, but sometimes we have to fall back on the earlier procedure in order to get accurate diagnoses in difficult cases.

Searching for stones is by no means the roentgenologist's only share in the examination of the urinary system. He can also tell whether there are two kidneys or not. Since now and then a person is born with but one, it is obvious that this state of affairs must be ruled out before a surgeon undertakes to remove a diseased kidney.

Kidney infections are not infrequently seen, tuberculosis being probably the commonest as well as the most serious. X-ray examination will show how much tissue has been invaded or destroyed, which, from the standpoint of treatment, is just as important as proof that infection exists.

But in such conditions as Bright's disease (nephritis) X-ray study is of little or no use. This is important to remember; it is no more essential to know the advantages of any sort of examination than to know its limitations.

Some people have a displaced kidney or one sufficiently movable to cause occasional kinking of the ureter leading from it. The symptoms of this condition are so similar to those of obstruction by ureteral stone that X-ray examination by the intravenous method is extremely valuable; the ureter, filled with dye, can be seen distinctly in most cases, kinks and all.

CHAPTER IX

The Roentgenologist Invades the Maternity Ward

IN 1896, shortly after Roentgen discovered X rays, someone suggested that they might be used to diagnose pregnancy and in 1897 the skull of an unborn infant was actually seen for the first time on a plate of the mother's abdomen. But since an exposure of an hour and a half had been required to make this plate roentgenologists did not at once invade the maternity ward. Today, however, we play an important part in the care of both mother and child.

For a long time X-ray examination was used to determine whether pregnancy existed. We could occasionally demonstrate the fetal bones as early as the eighth week and after the fifth month they became more and more plainly visible. Of course, this is not so important now for we have more modern tests which reveal pregnancy much earlier than this—the Ascheim-Zondek, requiring forty-eight hours, and the skin reaction of Falls, Freda, and Cohen, requiring only an hour. But the X-ray film still has its uses—in that often baffling condition known as false or phantom pregnancy, in those tragic cases where a woman has mistaken a tumor for pregnancy, and when twins are suspected, or hoped for.

MEASURING THE PELVIS

Some years ago we had at the hospital an accountant who married one of our nurses and set up in town in business for himself after leaving us. One day eighteen months or so later I found him and his wife in my office.

"Good morning, doctor," cried Mr. Welton, springing up from his chair. "Have you a few minutes free? I . . . we . . . that is . . . well, I wanted to . . ."

"The fact is, doctor," broke in young Mrs. Welton, "I'm going to have a baby and Dr. Morrison and I have been telling Tom how you measure the pelvis. Not that I know much about it, but I do remember a little you said in your lectures when I was in training."

"Thank you," I said. "Sometimes I think those lectures to the nurses are time completely wasted but you give me fresh hope."

The girl smiled at me and for the thousandth time I reflected how much early pregnancy adds to the beauty of young women. Later their bodies may grow flabby and misshapen from childbearing but the early months of a first pregnancy only accentuate the bloom and radiance of normal maturity and add a sort of happy aura to biological fulfillment.

But Mr. Welton was speaking again. "Of course I want everything done exactly right, you know that, doctor. But I never heard of the examination Louise is talking about. And besides someone told me that X rays are bad for . . . for the baby."

"I think probably the person who said that meant X-ray treatment. We do avoid that during pregnancy—at least we avoid treatment over the pelvis and abdomen. But it's perfectly safe to make films. With modern apparatus the exposures take only a few seconds."

Welton looked relieved but there was still uncertainty in his voice when he asked, "And you can really measure the bones of the pelvis accurately?"

"Oh, yes. The error amounts to no more than a few millimeters. We've checked that over and over."

"You see, Dr. Morrison was right," said young Mrs. Welton triumphantly.

"But how do you do it?"

Watching Welton's alert intelligent face, I felt my momentary annoyance disappear. Certainly I was busy, but who, after all, had a better right to my time and who a better right to ask that question? I leaned forward and cupped my hands together, in illustration.

"The pelvis, Mr. Welton, is a sort of funnel. We need to know whether it is normal in shape and size and whether there is any disproportion between it and the child. Let me show you what I mean. It's really quite simple."

I reached for the set of films I kept at hand for demonstration and set them up in the viewbox. The Weltons both gazed at them intently.

"We make two exposures—one with the patient propped up on a table, halfway between sitting and lying, and the other from the side, with her standing up. To her body we fasten a metal ruler notched in centimeters, at the same distance from the film as the diameter of the pelvis we wish to measure. Then, whatever distortion there is will be precisely the same for the scale as for the bones of the pelvis and all we need do is to read off the centimeters on the ruler—so many from one side to the other, so many from front to back. Now, notice on these films . . . "

Mrs. Welton gave a smothered little laugh, and looking up, I saw that her husband was staring fixedly at the viewbox.

"What are those funny looking streaks?" he demanded suddenly.

"Those 'streaks,' as you call them, are the baby's bones."

"The baby's bones!" he repeated after me.

"Yes. Here are the arms and legs, and this big round shadow lower down is the head."

"There's only one of it."

"There's only one baby. One head, two arms, two legs."

Young Mrs. Welton laughed again. "Now, aren't you glad you came? You're learning something." And to me she added, "Tom is so curious. He's never as happy as when he's found out something new."

Then Miss Randolph came in and the girl went out with her, looking back to smile at her husband.

He watched her go and turned back to me quickly. His expression had changed; there was now a new question in his eyes. Knowing that he had something more on his mind, I waited as patiently as I could.

Then suddenly he blurted out, "When you get these . . . these pictures, can you tell whether . . . if . . . well, you see, her sister had twins last year and . . ."

The laugh which had almost reached my lips was stifled there by the man's evident anxiety.

"Yes, Mr. Welton, we can tell you that too. As a matter of fact I'd like to have you and your wife come in with Dr. Morrison in a day or two and look at her films. And, when it's all over, I'll make you a present of them."

Of course things are not always as pleasant as this. Sometimes we find twins or triplets that are not welcome; sometimes we can see that the unborn infant is some sort of monster better never born alive; sometimes we find a dead fetus which must be removed if it is not expelled. But for the most part our pelvic measurements serve as guideposts to the attending physician; the misshapen and undersized pelvis is a common cause of difficult labor and injury to babies, and the obstetrician who is forewarned can do much to protect both mother and child.

Tuberculosis during Pregnancy

Many people do not realize that most women who develop tuberculosis do so before they are thirty-five—that is, during the first two-thirds of the child-bearing period. Every prospective mother should have her chest X-rayed early in her pregnancy to make sure that she does not have symptomless tuberculosis of the lungs. This is coming to be routine practice just as the Wasserman test for syphilis should be routine. In fact very few days pass at the hospital that one or two women do not come to my department to learn whether they have tuberculosis and to McDonald to find out whether they have syphilis.

Syphilis in the Newborn

But X-ray studies do not end with the mother. I am often asked to examine the newborn as well.

Sometimes the results are tragicomic. I remember that Dr. Morrison, one of our best obstetricians, came into my department a few years ago, closed the door of my office behind him, and confronted me with worried eyes.

"I'm in a jam," he said. "Will you help me out?"

"I will if I can, Morrison. You know that."

He sat down and leaned toward me confidentially.

"It's the Watson girl—the one who married that barnstorming aviator last year."

I nodded. Everyone in town knew how the girl had come home alone and how her father had treated her ever since.

"Old Henry—damn his eyes!—wanted to ship her away to have her baby, but the girl had more guts. She stayed right here. And if she'd only come to me sooner I could have prevented all this. But I never saw her until a month ago."

Morrison hitched himself up in his chair and went on.

"I never had a better patient. We get along fine. But . . . Well, the fact is that the baby isn't doing well and I'm afraid I've got a case of congenital syphilis on my hands. If I have McDonald run a Wasserman on the youngster and old Henry finds it out, he'll raise hell and jump all over the girl again."

I shrugged my shoulders and Morrison smiled crookedly.

"Nice mess for the prominent ultra-respectable, not to say snooty Watson family to have their only daughter deserted by a flyaway husband and their first grandchild a syphilitic! Of course I did all I could but I didn't get the girl early enough to prevent the child's being infected. I may be wrong about him, I suppose, but I don't think so. He's sniffling and he can't handle his food well."

"And what do you want me to do?"

"Well, if the baby is syphilitic, I must start treatment at once. What I wanted to ask you is how accurately you can diagnose congenital syphilis by X ray."

"Ninety per cent of the cases show definite changes in the long bones of their arms and legs during the first weeks of life."

Morrison got to his feet. "O.K. That's good enough for me. I'll send the youngster down in the next day or so. No one will think anything of that when you X-ray so many babies for enlarged thymus."

The films we made of this infant showed telltale patches of increased density in the bones and thickening of the periosteum (covering membrane of bone) and for years thereafter Morrison and the children's specialist to whom he afterward referred the child were put to many subterfuges to conceal from old Henry Watson the nature of the prolonged treatment they gave the baby and his mother.

Is a Baby Full-Term?

Occasionally ironic medicolegal quandaries arise in our best families.

One busy morning a lawyer whom I knew by sight called me on the phone and made an appointment for the afternoon. Promptly at four o'clock he appeared, accompanied by a woman in nurse's uniform who carried an infant I was sure must be less than a week old. I remember how obviously Miss Randolph's usually quiet face registered her disapproval of so young a child being carried about in public, but the attorney paid no heed to her.

"Can you determine by X-ray examination whether a baby is full-time or not?" was his blunt inquiry.

"The degree of bone development indicates whether an infant is premature, provided he is examined within the first few days after birth," I answered stiffly, feeling my hackles rise as they always do when policemen and lawyers ask me questions.

"Well, there's a damned good reason for wanting to know about this child. Suppose I explain a bit."

Seldom have I seen anyone expand more visibly than this attorney did thirty minutes later when I showed him our films of the baby's long bones and pointed out that they were indubitably those of a full-term infant.

"I had hardly dared hope for this," he exclaimed, rubbing his hands together. "You're sure about it, are you?"

"Certainly," I said quickly. "All roentgenologists agree that these little centers of density in the lower ends of the femurs, where the cartilage has begun to turn into bone, are seen only in the full-term, mature fetus."

A beatific expression spread swiftly over the lawyer's face.

"Then this child is lucky. He'll inherit a cool half-million dollars. You see, he was born five days ago, six months aft r his father was killed in a motor accident. The grandfather —I expect you can guess who he is, even though I've given no names—opposed his son's marriage and disliked the bride so much that he wrote into his will a provision that no offspring of the son's should inherit anything under that will if there was the least doubt about paternity. But if you can swear that this is a full-time baby, all three of us will get what's coming to us—you and me and the kid."

Enlarged Thymus Gland

There are fads in medicine just as there are in clothes and slang. A few years ago it was the fashion to suspect all newborn infants of having an enlarged thymus and many young parents were frightened half out of their wits lest their babies should die suddenly from this condition.

The thymus is a flat gland which lies just beneath the upper part of the breastbone. It is normally present and of considerable size at birth but shrinks gradually and by the age of thirteen or fourteen should have disappeared. Naturally if it is very large it can interfere with breathing because it lies just in front of the windpipe (trachea). Furthermore we used to be taught in medical school that there was a mysterious condition—known as "status thymicolymphaticus"—in which, among other things, there was a large thymus and which frequently caused death following slight injuries or from no visible cause whatever.

For a considerable period it was the rule in many hospitals to make routine X-ray films of all newborns in order to discover those with an enlarged thymus. I used often to see young fathers and mothers consumed with dread lest their babies should have this condition and die suddenly from it in their sleep. Now it is true that some infants do have thymus glands which are large enough to obstruct their breathing, but death from "status thymicolymphaticus" is no longer the dreaded specter it once was. It probably does occur now and then but certainly not nearly so often as we used to think.

Fortunately both the examination and treatment of this condition are simple. We make films of the chest with the infant lying on his face and on his side, first in inspiration and then in expiration. Since the windpipe (trachea) is filled with air, we can see its shadow as it passes down from the neck into the thorax. If the thymus is large enough to flatten the trachea or to push it backward, this is readily seen on the films. Once the diagnosis is made, X-ray treatment is given. The thymus is very sensitive to radiation and improvement is prompt, sometimes startlingly so.

But the fact remains that many symptoms formerly attributed to an enlarged thymus arise from entirely different causes and up-to-date obstetricians and children's specialists (pediatricians) do not now torture parents with the menace of sudden thymic death.

CHAPTER X

Some Basic Facts about Cancer

THE power which radium has to destroy tissue was first discovered, we are told, by accident. The story is that, early in this century, Henri Becquerel, the famous physicist associated with the Curies in their researches, carried a bit of radium in his pocket when he went to a scientific meeting in London and a few weeks later found an ulcerated sore on his skin underneath that pocket. Then Pierre Curie put radium on his arm in order to test Becquerel's observation and, when he too developed an ulcer which was slow to heal, they concluded that radium would probably destroy cancer tissue as well as normal flesh. From this deduction stemmed the medical use of this strange new element.

During the same period roentgenologists were learning that exposure to X rays produced redding of the skin and sometimes brought about marked improvement in tuberculosis of the skin (lupus). They accordingly went on to attack many other diseases, including cancer, with the same sort of enthusiasm that medical men in the last six or seven years have shown for the sulfonamide drugs.

With both radium and X rays the most spectacular use has probably been in the treatment of cancer. But about this subject there is so much misunderstanding that certain facts must be made clear before we go any further.

Cause of Cancer

No one now (1943) knows the real underlying cause of cancer. But we do know several of the contributing causes.

Mouth cancer, for example, often appears in areas which have been irritated for a long while by rough teeth, by poorly fitted dental plates, or by the hot smoke from a rapidly smoked pipe. Then too the weatherbeaten skin of persons much exposed to sun and wind is subject to cancer, and a certain proportion (probably not over 10 percent) of stomach ulcers eventually undergo malignant change.

It is also well known that chronic infection superimposed upon irritation often precedes cancer. Thus, the mouth of the uterus (cervix), usually torn at childbirth and often the site of prolonged low-grade infection afterward, is also one of the commonest sites of cancer in women.

Recently we have come to believe that some of the internal secretions, notably those of the reproductive glands (testicles and ovaries), influence the development of cancer in related organs. Certainly X-raying the ovaries and thus inhibiting their function retards the progress of cancer of the breast and castration restrains the growth of cancer of the prostate.

We also know that cancer is not caused by germs, as infectious diseases are, and that it is not contagious. No one ever "caught" cancer from anyone, not even from a cancer patient. Neither is cancer produced by eating food stored in electric refrigerators or cooked in aluminum pans, or by any diet however absurd, or by any degree of fear or anxiety or fatigue.

One very important thing about cancer is that it runs in families. Much study has been done on heredity in this disease. Maude Slye of the University of Chicago began working on this problem in 1908; in her laboratory are housed thousands of cancerous mice and their descendants and thousands of healthy mice whom she has made immune to cancer by breeding. Her observations and records cover more than one hundred generations of these animals—the equivalent of three thousand years' observation of human beings.

Her findings indicate that susceptibility to cancer is inherited as a "recessive characteristic," while resistance to cancer is a "dominant characteristic." Translated out of the jargon of the pathologist this means that, if a susceptible and a resistant individual mate, most of their offspring will be immune to cancer although they will be capable of transmitting to their descendants the susceptibility which remained latent in them. If, on the other hand, two cancer-resistant individuals mate, their offspring will not only be immune themselves but will pass on to their descendants the immune factor in their makeup.

By following these principles she has developed strains of mice in whom cancer appears in the vast majority of cases at the time and in the places which she foretells. She believes that heredity largely determines whether an animal will have cancer, and when and where. In her opinion equal care in human reproduction would develop men and women immune to malignancy.

In 1931 the Norwegian Medical Society published the most complete report ever compiled on the incidence of human cancer. It covered six thousand patients traced for twenty years or more. This study indicated that cancer occurs oftener among the brothers and sisters of cancer patients than among the general population, that there is more cancer among persons one or both of whose parents had the disease than among the unselected rank-and-file, and that there is a tendency for cancer of certain organs to recur in successive generations of the same family. These observations tally with those of Maude Slye in the United States.

However, restriction on human marriage, in the hope of controlling cancer, seems a distant hope. And certainly none of this explains why a stomach that has always taken care of meat and potatoes and cabbage and beer without a murmur should suddenly develop a cancer which will ultimately spread into the liver and lymph glands and result in death. Our knowledge of this disease is still only a narrow margin along the border of a great unknown.

Is Cancer Increasing?

To this question, frequently asked, we can answer yes with some qualifications.

Certainly we recognize cancer more often today than we did forty years ago. This is partly because we know more about the disease and have better means of discovering it than in 1902 and partly because cancer most frequently attacks persons over the age of forty and our population now has a larger proportion of middle-aged and elderly people than it had a generation ago.

It may be that this ancient scourge has periods of prevalence and periods of greater rarity. It may be that heredity has increased the number of us who are susceptible to cancer, and perhaps our habits of living and eating predispose to its development. On all these points we must admit uncertainty. But the fact remains that today cancer is one of the major hazards of middle and later life.

One reason for this is that it gives so little warning of its onset; there are no really characteristic symptoms of early cancer in internal organs. Malignant growths are not sore, they are not usually painful until well advanced and sometimes not even then. Unless they appear on the skin or in the mouth where they can be seen, in the breast where they can be felt, or in the uterus or bladder or rectum where they produce a bloody discharge, they are ordinarily not suspected for a long time. In the absence of pain, we are all prone to find an easy explanation for apparently trivial departures from normal.

For this very reason the experiment now going on at the Woman's Medical College in Philadelphia is interesting and important. A group of women are voluntarily undergoing regular, periodical examination for the express purpose of finding cancer in its incipient stage when treatment offers good prospect of cure. Already a few cases have been found in apparently healthy persons, but the final results will not be known for a good many years.

In the meantime there are two things everyone should remember about cancer: (1) if diagnosed early and treated skillfully it can be cured permanently, and (2) if quack methods are used recovery is impossible.

What Cancer Does to the Body

Life is made possible by the gearing together of organs in harmonious and automatic co-operation. Imagine—if you can—the state of a man who had constantly to admonish his stomach to do its duty and his lungs to absorb oxygen, to check his blood pressure every few minutes and order his heart to slow down or speed up accordingly, to oversee the workings of his internal ear so that he could balance himself, or to watch his cecum to make sure that it moved on promptly the lobster and salad he ate last night. The healthy body does all these things for itself, without conscious intervention.

But when illness befalls, this automatic co-ordination stops. Fortunately the breakdown is often temporary and fortunately too we are all built with a wide margin of safety. A man can lose a lung or a kidney or a good many feet of intestine or half his stomach and still enjoy good health. But when cancer appears, bodily co-ordination is over.

Somewhere a rebel cell has defied the regulations concerning growth and multiplication and set out to become bigger and better than any of its neighbors. Such cells never know when to stop. They spread through the organ in which they originate, they invade near-by lymph nodes, they find their way into the blood and are borne far and wide by it, they migrate through the lymph vessels more slowly but just as surely. In many cases they eventually work their way into the bone marrow and interfere with that most important function—the making of blood cells—so that severe anemia develops.

All these growing cells demand food and so the body calls on its savings deposits—the fat stored here and there against a day of need. But the fat is soon used up and the patient begins to lose weight and strength as he absorbs the poisonous material secreted by the growing tumor. Each organ separately does its best to carry on, but without co-ordination none of them can accomplish much. And the less each of them heeds the needs of the body as a whole, the worse conditions become. The body was not intended for anarchy, and when anarchy appears death is not far behind.

Quack Cures for Cancer

There are, I am ashamed to admit, a good many quacks in the United States who claim to cure cancer "painlessly and without the knife." "Satisfaction or your money back" is a phrase which recurs over and over in their advertising. Most of them use arsenic paste. Just why people should dread "the knife" and trust arsenic paste is beyond me. Arsenic cannot discriminate between healthy tissue and tumor tissue; it simply eats away whatever lies in its path. Occasionally, by accident, it may destroy all of the growth, but so might a blind surgeon now and then, by accident, remove a tumor in toto. And who would employ a blind surgeon?

Only by noting the length of time the patient lives after completing treatment can one guess how much cancer the arsenic paste left behind. Of all the hoaxes perpetrated on the American people in the name of freedom to choose their own physician and method of treatment, the cancer cure racket is the cruelest. No one knows this quite so well as those of us to whom the disfigured, dying victims come for help during their last days of life.

Proved Methods of Treating Cancer

Today we have three methods of treating cancer which have proved their curative power, another which is sometimes useful as an adjuvant, and several in the experimental stage which promise well for the future.

The three of definite proved value are surgery, radium and X rays. When one writes down that short list he has named everything of established worth in cancer treatment today. But with these three we could cure half or more of the victims of cancer if we could only get them under treatment early. Even when the tumor has begun to spread the case is far from hopeless; metastasis (spread) is often slow and can sometimes be stopped. This is not easy, to be sure; it demands a skillful physician and a courageous intelligent patient. But it can be done.

I shall never forget how I first learned this. Word came to us of the death of a woman on whom an autopsy was to be done because she had been treated five years before for advanced pelvic cancer. Everyone took for granted that the post-mortem would show recurrence of the growth. But a painstaking search revealed not the slightest trace of cancer. The patient had died from a hemorrhage in the brain, the result of sclerosis of her arteries.

Radiation in Cancer

Radiation treatment of cancer is a development of the last fifty years. How it produces cures is still not understood but we do know what happens when a cancer is attacked with X rays or radium. During the last fifteen or sixteen years a number of moving pictures have been made of the reactions of tumor cells under the impact of such radiation.

These films, made under the microscope, are most spectacular. First, one sees great numbers of cells flashing across the field of vision at high speed. Here and there one of them is dividing into two daughter-cells which share and share alike the nucleus of the parent-cell; this is the mechanism of heredity which makes cancer cells and mice and men what they are. The outstanding characteristics of these tumor cells are their incessant darting motion and their rapid multiplication.

But after a few hours' radiation all this is changed. The cells which once dashed about so rapidly slow down; they move more and more sluggishly, they divide slowly if at all. Finally, after further exposure, every single cell becomes motionless—frozen fast, as it were, in its own tracks. Not only does motion cease, but division and reproduction also end. Their life processes thus brought to a standstill, the cells themselves liquefy and are soon carried off the field.

This is what happens when we treat a tumor with radium or X rays. This is why it shrinks and gradually disappears.

Surgery and Cancer

Any cancer which is localized can be completely cured by operation. This is the best reason for early surgery. In 1942 the Mayo Clinic reported that between 1907 and 1938, 10,980 patients were operated on for cancer of the stomach at the clinic. Twenty-four percent of the entire number recovered completely, but sixty percent of those who came to surgery early were cured.

As the disease spreads, the task becomes harder. Not only must the parent tumor be removed completely but all the metastases as well. If these are confined to the near-by lymph glands the operation still has a good chance for success, but in many cases it is impossible to excise all the daughter-cancers without doing irreparable damage to vital structures. In these patients, a combination of surgery and radiation (with X rays or radium or both) must then be used.

Lead in Cancer

Lead is sometimes used as an aid in the treatment of cancer. It is injected into the blood stream and acts upon the circulation in the tumor in such a way as to cause degeneration of the growth. A few years ago we hoped for a good deal from this type of therapy but recently it has dropped more or less out of sight.

Experimental Methods

Two new methods of attacking cancer, both still in the experimental stage, promise well for the future. One of these methods consists in giving the patient a substance which has been made artificially and temporarily radioactive in the laboratory; as long as this material is in the body it gives off the same rays as radium to the tissues with which it comes in contact. For instance, a number of persons suffering from leukemia and polycythemia (diseases of the cancer family which involve the blood and the bone marrow) have been given radio-phosphorus; the bones absorb much of the phosphorus compound and, during its period of radioactivity, the bone marrow is therefore heavily irradiated by it. These patients have improved to about the same degree as those treated with X rays, but no one suffering from either of these conditions has ever been cured with any form of therapy. We expect, however, that research along this line will give us an effective method of irradiation which will be much cheaper than any type of radium treatment now in use.

The second important new way of attacking cancer is with neutrons. The neutron is an atomic particle having the same mass as the nucleus of the hydrogen atom but carrying no electric charge. Neutrons are made by that famous machine, the cyclotron, well known to magazine and newspaper readers by reason of the publicity given to the installation at the University of California. These atomic bullets stream out from a tube directly into the tumor in much the same way as X rays. There is no pain or discomfort connected with the treatment.

A good many patients with far advanced cancer, on whom surgery was impossible, have been treated with neutrons; the results have been promising although no complete cures have been made. But relief from pain and general symptomatic improvement are the rule. It is significant, we think, that neutrons seem to benefit particularly patients with cancer of the mouth, throat, and prostate—all types difficult to treat by ordinary methods—and those whose disease has already spread into the lymph glands.

We have at hand today, therefore, quite an armamentarium available for the attack on cancer: surgery, X rays, radium, lead, artificially radioactive materials, and neutrons. Skillfully employed they offer cure to many and relief to almost all cancer patients. The quack has nothing that can be compared with them. And, as surely as day follows night, we shall have something tomorrow better than anything we know today.

CHAPTER XI

Some Experiences with X Rays and Radium

WHEN I began studying X rays and radium, the radiologist seldom saw cancer patients except those who were considered hopeless or had developed recurrences after operation; his job in those days was to relieve their suffering if possible and to take them off the surgeons' hands. But as our knowledge has increased and our apparatus and methods have improved, the number of patients we see and the variety of conditions we treat have multiplied. Indeed radiation is now used not only for cancer but for many nonmalignant conditions also.

CHOOSING THE METHOD OF TREATMENT

People often ask whether cancer should be treated with surgery, X rays, or radium. That question cannot be answered categorically; too much depends on circumstances.

Suppose, for instance, that there is in your community an excellent surgeon but no equally competent radiologist; then, in most cases, operation will give the patient a better chance than radiatiton. If conditions are reversed, radiation might be preferable most of the time.

Often the combination of surgery and radiation will accomplish far more than either alone. Twenty years ago very few surgeons knew anything about radium and X rays and few radiologists knew anything about surgery, and each was more or less contemptuous of the other. But today there are more and more teams of surgeon and radiologist working together, supplementing each other. Having wasted much breath arguing the relative merits of surgery and radiation in the treatment of cancer, we are at last finding that co-operation will do much where argument did nothing.

Among medical men there is now fairly general agreement that certain types of cancer are best attacked primarily by surgery, others primarily by radiation, and still others by combined methods.

In the group ordinarily best treated by the surgeon fall the following:

Cancer of the stomach and intestine, including the large bowel.

Cancer of the esophagus (tube leading from throat to stomach).

Cancer of the pancreas (digestive gland near stomach).

Cancer of gall bladder and bile passages.

Cancer of kidney, bladder, and prostate.

In the group usually best attacked with radiation are the following:

Cancer of the skin (which seldom appears except on the face and neck).

Cancer of the lip.

Cancer of the pharynx (upper throat).

Cancer of the cervix of the uterus (outlet).

Lymphosarcoma and Hodgkin's disease (malignant tumors of the lymphoid tissues).

Multiple myeloma (a malignant tumor of bone).

Round-cell sarcoma (malignant tumor arising from connective tissue cells).

Ewing's tumor (another malignant tumor of bone).

Generally speaking, the medical profession believes that many malignancies are best treated with a combination of surgery and irradiation. Among these are the following:

Cancer of the mouth and jaw.

Cancer of the breast.

Cancer of the thyroid gland.

Cancer of the ovary.

Sarcoma of bone.

However we must all remember that these groupings are not rigid but constantly changing, that no hard and fast rules can be laid down for individual patients or tumors. Each case must be studied on its own merits and treatment planned accordingly. Doctors treat the patient, not the disease.

Furthermore, new developments of technique and new discoveries may at any moment make all such tabulations as these ridiculous and untenable.

Cancer of the Breast

This is one of the commonest and most dangerous of malignant tumors. In 1920 the reported deaths from cancer of the breast in the United States numbered 6,665; in 1929, 10,204; in 1933, 13,000; in 1941, 15,488. The length of the entire illness averages between three and four years.

Although cancer of the breast is an old well-known disease, not until 1894 was a surgical operation devised which gave any real hope of cure. Even then, nearly one-fourth of all patients operated on died because of surgical reaction and only about 5 per cent lived as long as three years. But since the ninety's surgical technique has improved so much that the radical operation for breast cancer now has a direct risk very little greater than that of appendectomy, while from 23 per cent to 70 per cent of the patients show at least five-year cures—i.e. live for five years without evidence of recurring disease.

By combining surgery and radiation, even better results can be obtained, especially in cases where spread has occurred into the lymph glands in the armpit (axilla) or above and below the collarbone (clavicle). Some doctors report that over half their patients with such extension are alive and well five years after treatment by the combined method.

Sometimes it is best to give radiation after the operation, sometimes it should be given both before and after. When the disease has begun to spread over the body (metastasize), radiation is usually indicated both before and after surgery.

Cancer of the breast in young women is not infrequent; it is also extremely dangerous, particularly during pregnancy. It grows rapidly and metastasizes quickly. Preoperative and postoperative radiation should therefore be given. Furthermore, most doctors believe that the patient has a better outlook if her ovaries are irradiated at the same time; it is definitely known that the secretion of the ovaries stimulates the growth of breast tumors. Unless these cases are to go on to an early death, prompt vigorous treatment—both radiological and operative—is imperative.

In older women cancer of the breast sometimes remains localized for a long time and one may be able to get unbelievably good results with radiation alone. I remember my first experience of this sort as vividly as though it had happened yesterday.

Mrs. Baker Surprises Us

One day an elderly couple, poorly dressed and ill at ease, came into my office with a note from the physician in the small town where they lived. The note read in part: "Ask Mrs. Baker to show you her breast and be prepared for a shock."

Mrs. Baker was a thin gaunt woman who looked more than her sixty-two years; her face was weatherbeaten, her hands brown, and her fingers bent. Her eyes were bright with anxiety. With manifest uneasiness she permitted herself to be led away to a dressing room by Miss Randolph.

"Pa," she said from the doorway, "don't you go away now."

Mr. Baker shook his head in the promise she desired and flung one thin leg over the other as he turned to face me.

"I been after her to go to a doctor for more than two years now," he explained. "But she was afraid. She never was much for cuttin'. She never paid no heed till last week. Then the doctor scared her pretty bad. He said if we didn't do something right now it was goin' to be too late. And he give us that note to fetch to you. But he's kind of young and I expect he exaggerated some."

There was almost a question mark in the man's face on the last sentence. Hurriedly I turned aside to read and sign some of the reports lying on my desk. How could I answer him when I had not yet examined his wife? Why had she waited while cancer devoured her flesh? "Not much for cuttin'." How often I had heard that remark or something very like it. "Not much for cuttin'"! And so, by waiting, they doomed themselves. I told myself that it was not my fault that there were foolish people in the world, and yet my annoyance was shot through with pity when I cast a glance at Mr. Baker's worried face, his gnarled brown hands, his shabby trousers.

When Miss Randolph came to say that the patient was ready, the old man sprang up with an agility that surprised me. "Can I go along?" he asked. Something in his voice told me that romance might have died but love had not.

Timidly Mrs. Baker opened her examining wrapper. There, on one side of her chest, in place of the breast was an open ulcerated mass as large as my fist from which ran a little trickle of thin bloody fluid. I put out a hand, hesitated a moment.

"I guess it's pretty bad, ain't it?" said Mrs. Baker, glancing nervously at Miss Randolph, whose expression of dismay was unmistakable.

Hastily I changed my intended reply. Reaching for a gauze sponge, I said casually, "Oh, I've seen worse. Now, if you'll raise your arm, please . . ."

But to my surprise I could feel only one or two small hard lymph glands in the armpit and none in the vicinity of the collarbone. In order to rule out some rare disease simulating cancer I called in McDonald who snipped out a bit of the mass for study under the microscope. He reported that so far as structure went it was ordinary cancer—ordinary cancer behaving in an extraordinary way.

"I noticed it three years ago," said Mrs. Baker. "But I didn't think much about it. It didn't hurt nor bother me none till lately when it began to run this way. I didn't like that."

I was not surprised to hear this. Shabby as her clothes were, they were spotlessly clean; her hair was combed neatly, her skin was clean. And, bit by bit, she was regaining her composure. I thought I knew what was going through her mind; she had faced life for a long time and she could go on facing whatever life brought her, even though that were death.

"Do you reckon an operation will be necessary?" asked her husband when I straightened up at last and tucked the examining wrapper together again.

"Now, Pa," said Mrs. Baker, "ain't I told you I won't have no cuttin'?" She stood up and looked at me inquiringly. "You think maybe X rays would heal it up?"

I did not think so. I considered her doomed. But I did not tell her so, or her husband. Instead I took her down to the treatment room, made my measurements and calculations, and then and there gave her her first dose of X rays.

I remember how her rapid improvement amazed us all. First the ulcerating mass became dry, then it began to shrink. Mrs. Baker gained a few pounds, lost her worried look, even began to make little jokes with Miss Randolph about her former dread of doctors. I had McDonald see her again and enjoyed the astonishment in his face when he examined her.

"This woman has no business being alive and here she's getting well," he exclaimed when we talked the situation over afterward.

And she did get well. The tumor disappeared, the skin healed over, and Mrs. Baker went her accustomed way until three years later when she died suddenly of a stroke (cerebral hemorrhage). That taught me to beware even of my own opinions.

Take Nothing for Granted

It is never wise for a doctor to be too sure of anything. Shortly after McDonald came to this hospital I had proof of that.

I was in his laboratory one afternoon when he said to me, "Look here. I want to show you something."

The "something" was a piece of tissue the size of an egg.

"This mass was taken out of a woman's breast last week, right here in this institution, mind you. But I was not asked to make a frozen section of it, I wasn't even in the surgery when the operation was done. The interne tells me that Dr. Sidney said there was just this isolated, freely movable tumor which he was sure was only a cyst, and according to the chart no lymph glands could be felt in the armpit or around the clavicle. Now the question is: What am I going to do about it? I just called Sidney to tell him that my routine sections show carcinoma and he was politely incredulous. I know he doesn't believe it. And how am I to make him do the right thing by his patient?"

There was nothing I knew of that McDonald could do; both he and I are merely employees of the hospital and Sidney was and still is one of the older major surgeons on the staff—a man who prides himself on his clinical ability and is inclined to criticize the younger doctors for depending too much on laboratory and X-ray examinations.

But three months later the matter was taken out of all our hands. Dr. Sidney came in one morning, bringing the patient with him. She had turned up in his office the day before with a crop of small nodules below her collarbone (clavicle), in her armpit (axilla), and along the base of her neck. In spite of all we could do, in another ninety days she was dead. Soon afterward, at the suggestion of the chastened Sidney himself, the hospital staff made a ruling that in all cases where cancer was a possibility the pathologist was to be on hand and make and report on frozen sections of the tissue removed, before the incision was closed. With that action, which closed one more avenue toward tragedy, McDonald felt himself fortified for the future.

A Husband Makes Complications

We expect patients to be a problem but sometimes their relatives are worse. I remember a physician for whom I once worked saying that he would rather see a man enter his sanatorium with tuberculosis of every organ in his body rather than come bringing his wife and family with him. I do not usually feel that strongly about relatives but sometimes I am close to it.

Dr. Douglas, a year or so ago, had a middle-aged woman

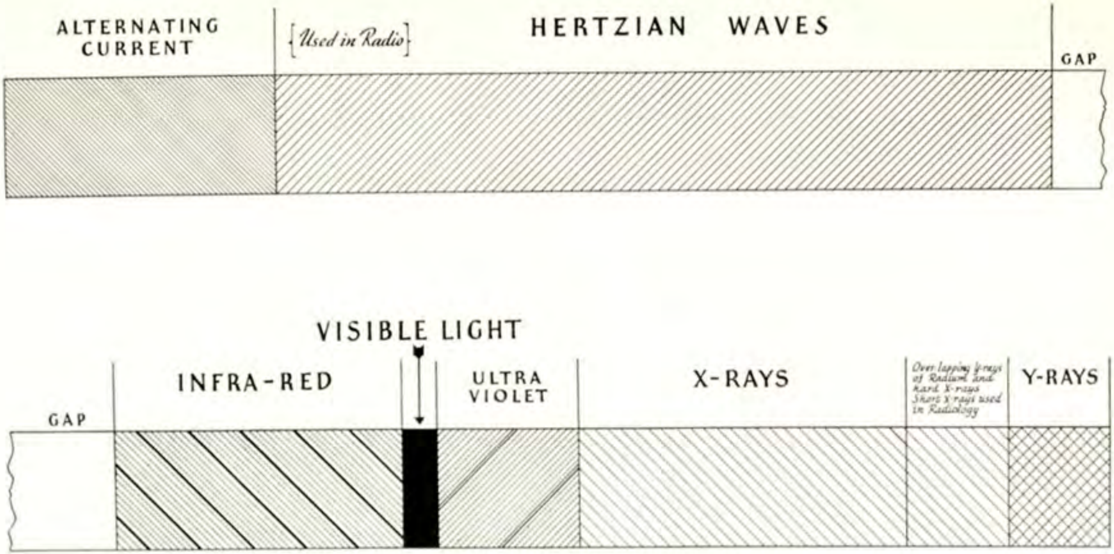

PLATE 1. Chart of the Electromagnetic Spectrum

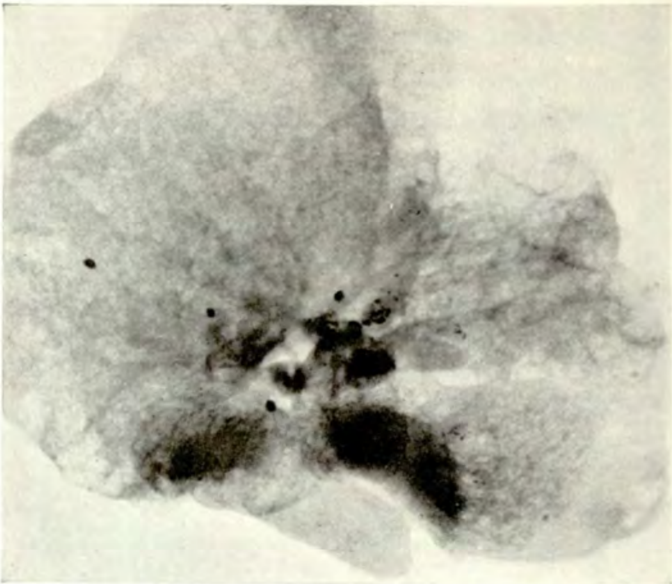

PLATE 2. This is an X-ray photograph of a lung that has been removed from the body. Much of the lung tissue, however, still contains air. The small dense spots are areas of tuberculous infection which have healed and in which the blood has slowly deposited calcium (lime salts) in order to make the healing solid and permanent. These calcified areas are hard and rocklike.

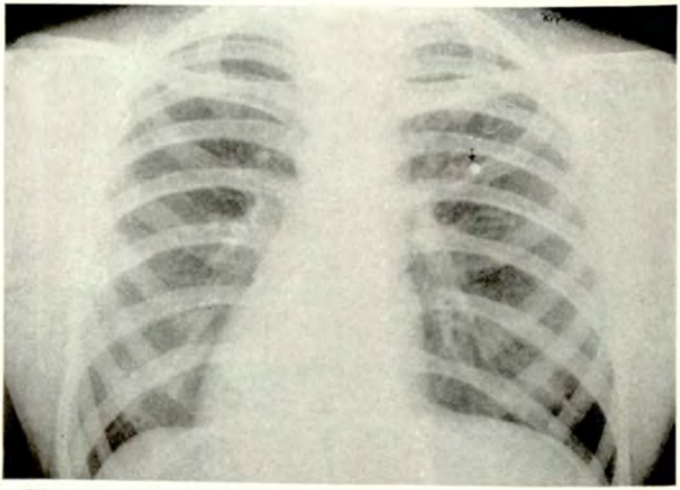

PLATE 3. This X-ray film of a child's chest shows healed tuberculosis in the upper right lung. Notice the small, dense, round spot; this is a calcified area like those shown in the picture of the excised lung. Around it are strands of scar tissue where healing occurred without the deposit of calcium (lime salts). Unless it is exceptionally heavy, tuberculous infection in children beyond infancy tends to heal in this way.

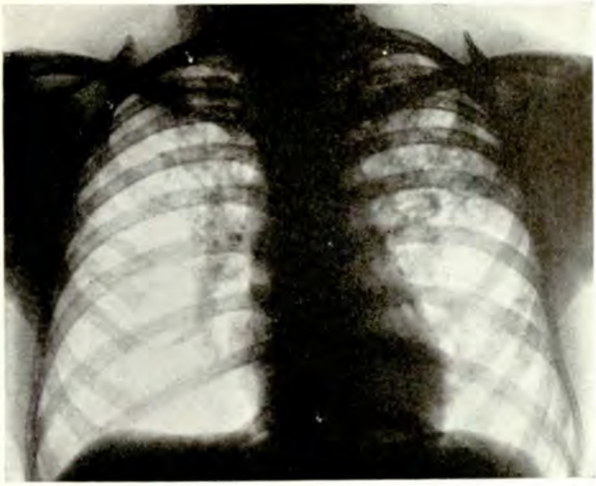

PLATE 4. This X-ray photograph of a chest shows active tuberculosis of the lungs of the ordinary type. The cloudy, mottled areas in the upper part of each lung show where the infection is. Contrast them with the comparatively clear appearance of the lower part of each lung. The disease is more advanced, and probably older, on the left side than on the right. In spite of all this tuberculosis, the patient—a young man in his twenties—had almost no cough and few other symptoms, at the time when this examination was made. That is why X-ray examination of the chest is so important in discovering tuberculosis of the lungs.

PLATE 5. This X-ray film was made of a young woman's chest one week before she died. She had been ill for three months but had no symptoms to direct attention to her lungs. Notice the tiny spots of uniform size evenly distributed throughout both lungs. This condition was a diffuse tuberculosis disseminated by the blood stream. The diagnosis in this case was proved by post-mortem examinati

PLATE 6. This is the side view of the chest of a patient who had a cancer developing inside his thorax. The large dark shadow toward the back of the chest was caused by fluid forming between the lung and the chest wall as a result of the tumor. In front of it you see a clear zone; this is air-filled lung next to the front wall of the chest.

PLATE 7. This chest film shows what fluid accumulated between the lung and the chest wall looks like. Notice the clear left lung and the opacity which conceals all detail in the right lung. Fluid forms in this way in several conditions, among them tuberculosis, pneumonia, and cancer of the lung. In this case post mortem showed cancer.

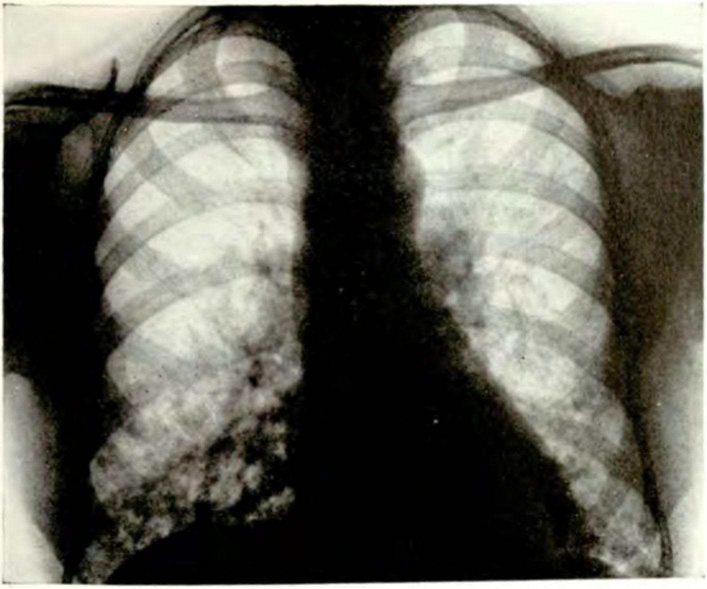

PLATE 8. This chest film was made a few weeks before the patient died of cancer of the thyroid gland. Notice the irregular, scattered areas of cloudiness in each lower lung. These are daughter cancers (metastases), spread through the blood and lymph from the parent tumor in the thyroid. This diagnosis was proved by post-mortem examination.

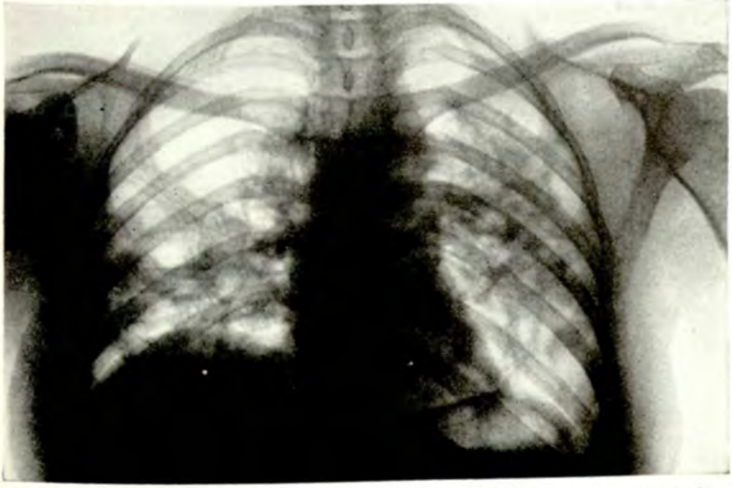

PLATE 9. Notice the cloudy areas scattered throughout both lungs. This is a diffuse bronchopneumonia. Also notice how high the right diaphragm is; in pneumonia the diaphragms are often elevated and immobilized because of an accompanying pleurisy. Post-mortem examination of this patient showed that her pneumonia was caused by the germ called Friedlander's bacillus.

PLATE 10. This is an X-ray photograph of a small child's legs. Notice how the bones above and below the knees are curved and misshapen. This child has both knock-knees and bowlegs as the result of rickets. The deformities will be permanent.

PLATE 11. This baby has scurvy. There is atrophy of the bone (unusual transparency, due to lower calcium content than normal). The ends of the bones are widened and somewhat deformed. Along the right thighbone (femur) there has been a hemorrhage beneath the periosteum (the membrane which surrounds the bone).

PLATE 12. This baby was born with syphilis. Notice the layers of elevated periosteum (the membrane around the bone) along the thighbone (femur) and along the bones below the knee. The upper end of the tibia (shinbone) is swollen. These changes in the long bones are characteristic of congenital syphilis in infants.

PLATE 13. This patient—a lad in his teens—had a nontuberculous infection of the lower end of his thighbone (femur). The bone broke at the site of the infection. Notice how the shaft of the bone has been displaced and how the lower end of the shaft lies farther forward than the knee. The large mass in the soft tissues of the thigh, behind the bone, is the abscess which formed there as the result of the infection in the femur (osteomyelitis).

PLATE 14. This X-ray photograph of a knee shows what a malignant tumor (sarcoma) of bone looks like. The growth started in the upper end of one of the bones (tibia) near the knee. This bone has enlarged but inside it you can see patches of transparency where bone tissue is being replaced by invading tumor cells. The patient died when the cancer finally spread (metastasized) into her lungs.

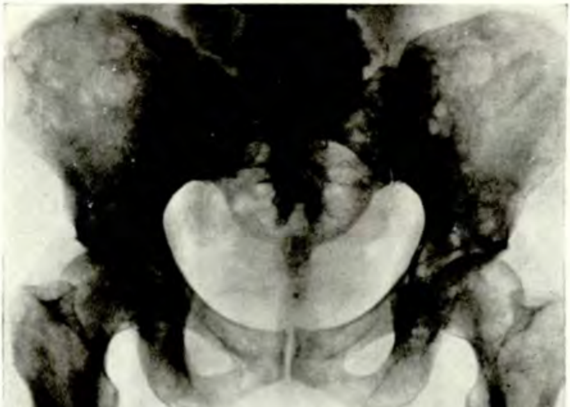

PLATE 15. Notice the transparent spots scattered throughout the bones of the pelvis. They mark the areas where hard normal bone has been replaced by cancer tissue. The parent tumor in this case was in the breast. After the bones were invaded the patient suffered severe pain, but we were able to give her relief with X-ray treatment so that, when this film was made, she could walk with very little discomfort in spite of the widespread involvement of her skeleton (spine, pelvis, neck, shoulders).

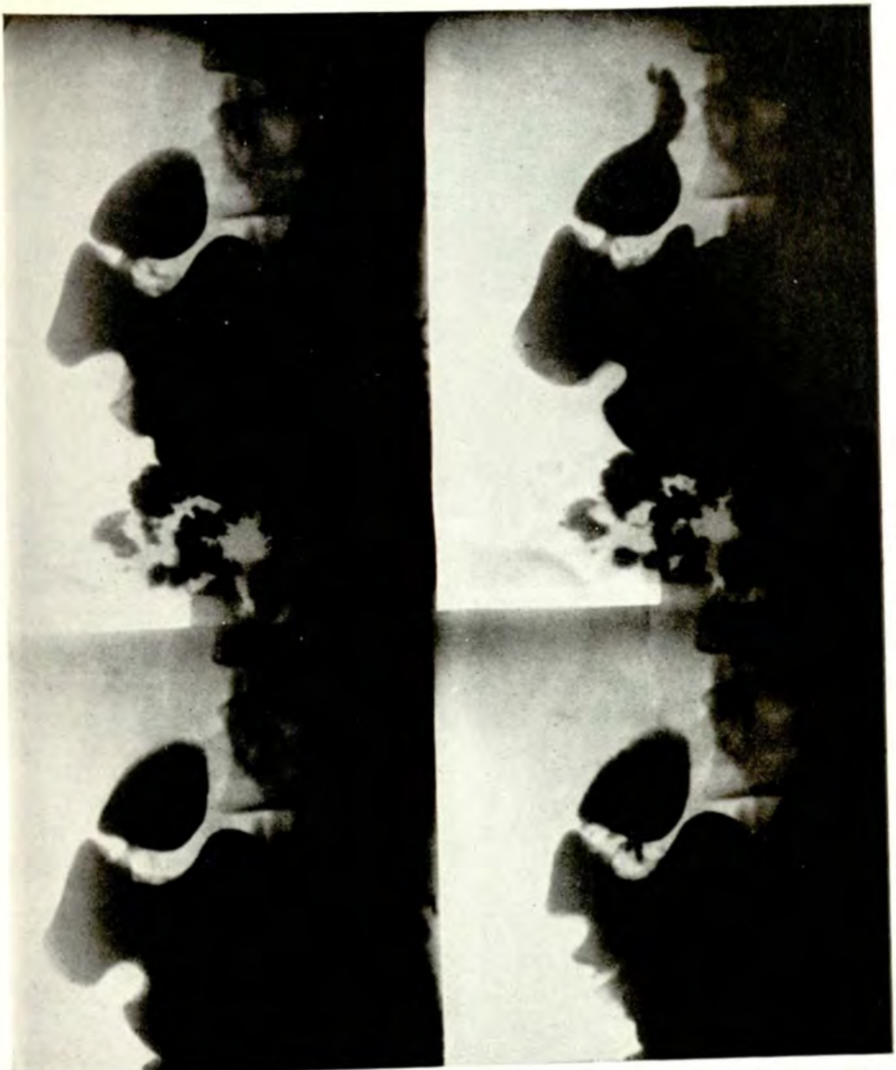

PLATE 16. This is a series of four films made in rapid succession. They show the lower end of a normal stomach and the first portion of a normal small intestine (duodenum). The triangular shadow at the top of the picture is the first part of the duodenum, called by X-ray men the "cap" because it is supposed to look like a bishop's headgear. Below it you can see a thin streak of barium in the passage-way between the stomach and the duodenum (the pyloric canal). The remainder of the dense shadow is the barium-filled stomach. The notches along its borders are waves of contraction in the muscles of the stomach wall (peristalsis).

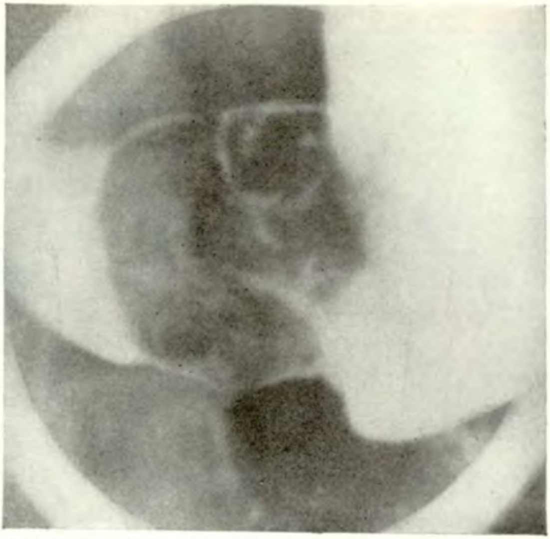

PLATE 17. Certain types of stomach cancer produce an irregular mass growing out into the cavity of the stomach. When the patient drinks a barium mixture, the barium tends to stick in the cracks and crevices of the growth. Here is the X-ray photograph of such a cancer. I squeezed out most of the barium by pressure before making the film but some stuck behind on the surface of the tumor. The diagnosis in this case was confirmed at operation.

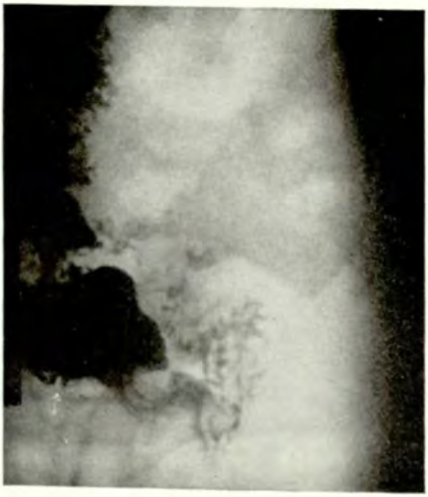

PLATE 18. An ulcer eats a little hole into the wall of the stomach (or duodenum, as the case may be), and the muscular tissue in the vicinity of the ulcer is in spasmodic contraction most of the time. This causes the margin of the stomach (or duodenum), as we see it on the X-ray screen or film, to be irregular. This picture shows such irregularity due to ulcer in the first portion of the small intestine (duodenum).

PLATE 19. Large stomach ulcers may eat such big niches into the wall of that organ that, after the patient takes a barium meal, a considerable quantity of barium works its way into the pocket of the ulcer. This X-ray photograph shows barium collected in such an ulcer pocket projecting beyond the margin of the stomach itself.

PLATE 20. An ulcer at the gateway between the stomach and the small intestine (the pylorus) usually causes spasmodic contraction of the muscle which forms the pylorus. Then food stays in the stomach longer than normal. Here, six hours after the patient took his barium meal, it is all still in the stomach whereas it should by this time have been in the lower part of the small bowel. Operation showed an old ulcer at the pylorus, with almost complete obstruction of the passageway by scar tissue.

PLATE 21. This man had a tumor arising in lymph glands in the back of his abdomen, near the spine. This tumor, pressing forward as it grew, finally caused an obstruction of the small intestine a short distance beyond the stomach. Here, five hours after he took a barium meal, we see a considerable residue in the stomach and a pocket of barium in the duodenum (first portion of the small intestine). Lower in the abdomen there is barium scattered through the coils of the lower small bowel (ileum). At this time the stomach should have been entirely empty, but pressure from the tumor prevented normal emptying.

PLATE 22. This patient had hemorrhoids. Before operating on her the surgeon asked for a barium enema. Watching on the fluoroscopic screen as the barium mixture flowed into the bowel, we noticed a little delay a short distance above the rectum. This picture shows the appearance of this part of the intestine, well filled with barium except for a gap of about two inches. Operation a few days later showed a very early cancer. It was removed, the patient recovered and has remained well.

PLATE 23. This X-ray photograph shows several large stones in the kidney. Notice how the spine is bowed to one side. We often see such curving of the vertebral column in kidney infections and kidney stones; it is caused by muscle spasm in reaction to the disease and not to anything actually wrong with the bones of the spine. This patient, in addition to these stones, had a long-standing infection of the kidney.

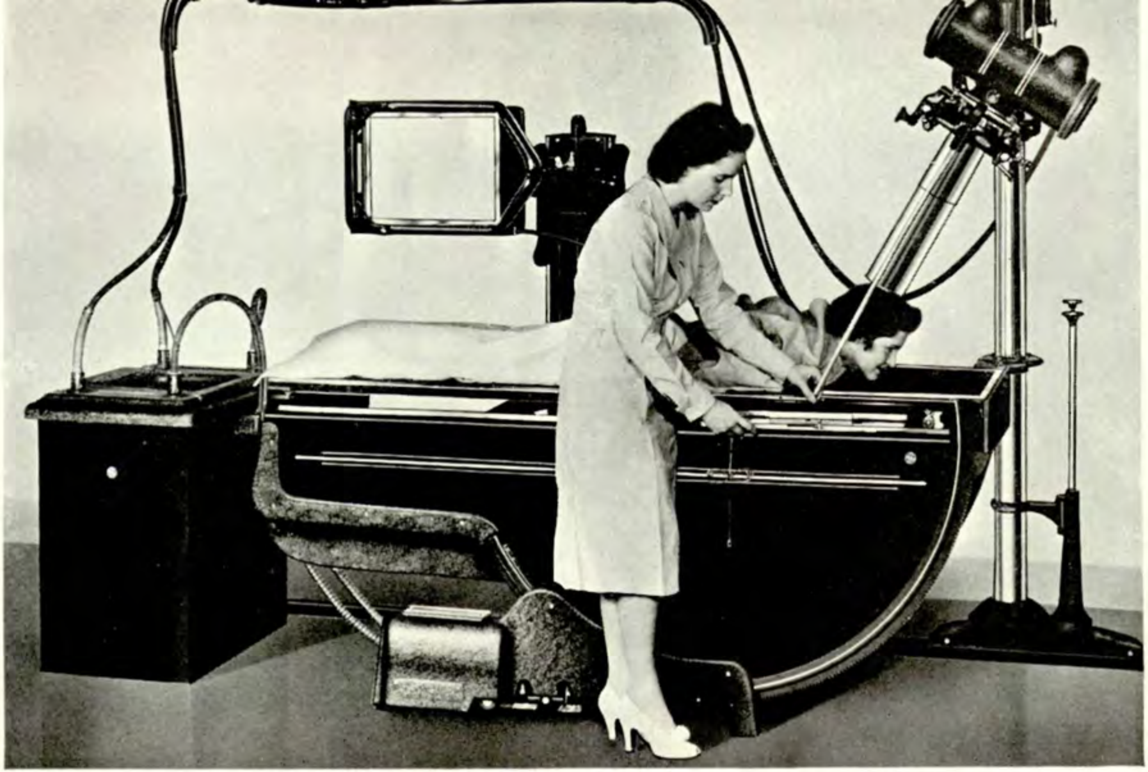

PLATE 24. This is a modern X-ray machine in use. The technician is about to make a film of the patient's sinuses. Notice how the tube is enclosed. Also notice the thick, insulated cables going to the tube from the transformer at the left—the source of the high voltage current required for the production of X rays. The oblong screen behind the technician is the fluoroscope on which we watch the beating heart and study the moving stomach. (Photograph, courtesy of the General Electric Xray Corporation.)

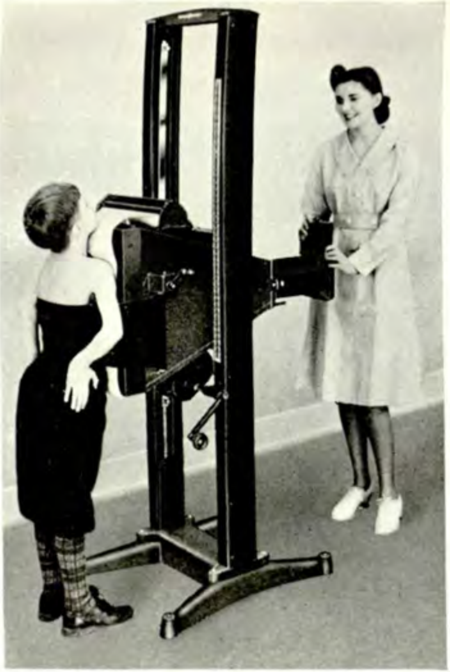

PLATE 25. Here is one of the new machines which make miniature films of the chest. Somewhere behind the boy are an X-ray transformer and an X-ray tube centered on his thorax. The lad stands with his chest against a fluoroscopic screen, upon which an image is cast when the X rays pass through his body. The technician is operating the camera which photographs the image thrown on the fluoroscopic screen. The roller towel effect in front of the boy is a purely sanitary precaution. (Photograph, courtesy of the General Electric Xray Corporation.)

PLATE 26. Here is the treatment room of a million-volt X-ray setup. See how far it is from being a chamber of horrors. The patient lies comfortably on a thick mattress. The beam of X rays emerges silently from the cylindrical shaft projecting downward from the ceiling. In the wall at the far end of the room is a window through which the operator watches the patient. No wonder people sometimes cat-nap during their treatments. (Photograph, courtesy of the General Electric Xray Corporation.)

PLATE 27. Here is a mobile X-ray unit being used to X-ray a welded joint. It was machinery like this which was employed to examine the welds at Boulder Dam. It is machinery like this which is now X-raying boilers for the Navy and weldings for Victory ships and airplanes. (Photograph, courtesy of the General Electric Xray Corporation.)

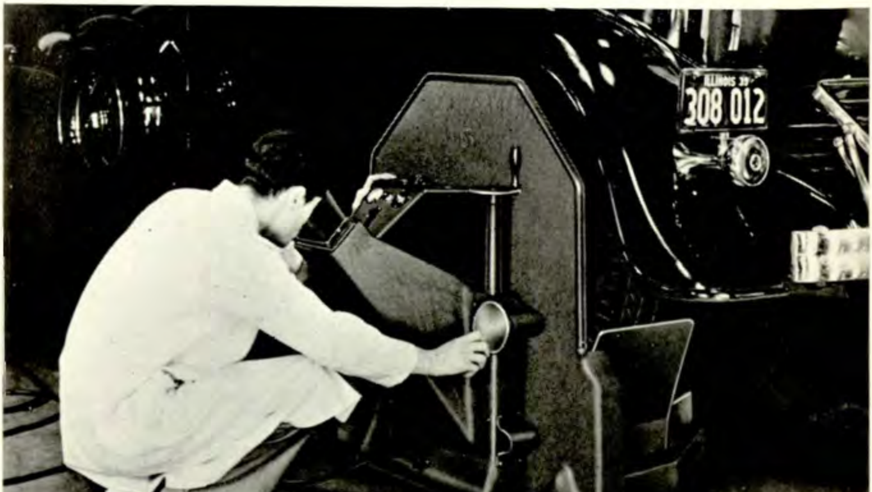

PLATE 28. In a day of tire shortage X rays can help you make your old tires last longer by locating hidden defects in their walls. Somewhere off-stage the owner of this car is undoubtedly pacing the garage floor in a fever of excitement. "Will it be a—patch or a re-cap?" (Photograph, courtesy of the General Electric Xray Corporation.)

in for breast cancer. He did a nice operation and we gave her heavy radiation, but the tumor had begun to spread before this and now there was no stopping it. A few months later Douglas had me re-examine the patient because of severe pain in her lower back. My films showed what I expected—extensive invasion of the bones of spine and pelvis by cancer.

As time went on other bones became involved, and finally she had scattered areas of destruction in her skull, her neck, her ribs, many of her vertebrae, her pelvis, and even her arms and legs. Fortunately she was one of the persons who get relief of pain from X-ray treatment, but unfortunately she had a husband who could not face facts and would not allow anyone to tell his wife what was wrong.

Her own diagnosis was arthritis and as soon as the radiation freed her from pain she insisted on getting up and going about her housework. With so many bones involved I knew it was only a matter of time until they would begin to break under the stress of all her activity, but her husband would not allow me to warn her of this possibility. The result was that one morning when she started to get out of bed she broke her hip, and shortly afterward the other also.

Thereafter her course was rapidly downward and, so far as I know, she died still thinking she had arthritis. Throughout the whole affair her husband remained stubbornly unconvinced that these fractures and much of her subsequent suffering could have been avoided by telling her the truth and persuading her to avoid overactivity.

The Unexpected Happens

Sometimes the things we are able to do for people give us great satisfaction.

A few years ago Miss Randolph told me, when I returned to the department after lunch, that a man had just called up to ask for an evening appointment.

"I explained that you saw only emergency cases at night, but he seemed so upset I thought perhaps I'd better speak to you about it."

When I spoke to him I too caught the inflection of distress in Mr. Pierce's voice and so I told him to meet me at the hospital the next evening at eight o'clock.

He turned out to be a tall gray-haired large-framed man in his middle sixties, who gave the impression of having lost a great deal of weight rather recently. He apologized for asking me to see him after hours.

"You see, doctor, I'm a mail carrier and I work till six o'clock every day except Sunday."

But again there was something in the way he spoke which told me there was more than that behind the evening appointment. Meanwhile I had noticed a mass bulging out below the collar of his shirt when his coat fell open, and had begun to canvass the possibilities. (Any doctor worth his salt begins to tabulate his observations the instant he sees a patient; there is often as much to be learned in this way as in any other.)

Mr. Pierce fumbled in his pocket and handed me a folded slip of paper. It was a prescription blank signed by Dr. Benson.

"The bearer, Joseph Pierce, has Hodgkin's disease. I have advised him to have X-ray treatment. Any consideration you show him I will appreciate."

The diagnosis did not surprise me; Hodgkin's was the first thing that came to my mind when I saw the lump below Pierce's collar. Examination showed that there were other masses of enlarged lymph glands in each side of his neck, in each armpit (axilla), above and below each collarbone (clavicle), and in both groins.

The patient told a familiar story. "I've been going downhill for maybe six months. Haven't had pep enough to do anything when I got home from work or go anywhere in the evenings. But I didn't think much of it until I had to get bigger shirts. I always wore a fifteen and now I have to have a seventeen on account of these things in my neck. But the funny thing was that I lost weight while I was getting these lumps. Of course they came on sort of gradual, but here lately, they've been growing pretty fast and so I went to see Dr. Benson last week. He told me I should come to you for X-ray treatment."

Mr. Pierce stopped there but—as always under such circumstances—a question hung in the air between us, unspoken. "Can you cure me? Will I get well or? . . ."

But I have learned to ignore these unvoiced queries. I went on with my examination, noting down the measurements of the masses of enlarged nodes as I went. Then I jabbed his ear, took blood, for red and white counts, and made some slides so McDonald could study the blood cells. When I finished I sat down and looked at my patient.

"I am sure Dr. Benson's diagnosis is right, Mr. Pierce. But I want to have our laboratory man look over these smears of your blood before I discuss treatment with you. We don't want to make any mistakes, you know."

Mr. Pierce leaned forward. "About how many treatments will it take, if what I've got is . . . is this Hodgkin's disease?"

"Oh, I would want you in here two or three times a week for about an hour each time. The whole course would take probably four or five weeks."

The man's face fell. "I was afraid of something like that, doctor. I don't think I can do it."

"Now don't leap to conclusions, Mr. Pierce. It won't cost as much as you think. This disease doesn't need as heavy treatment as cancer. . . ." I emphasized the last word, hoping no one had told the man that Hodgkin's disease is actually a close relative of cancer ". . . and I'm sure we can arrange terms that you can meet."

"It's not the money so much—though that's important, in a way, too. It's the time. I can't take so much time off, doctor."

"Nonsense, man. If you go on like this you'll be taking six days a week off, in very short order. Of course you can take the time."

"No, I can't, doctor. That's where you're wrong. You see it's like this. I've got four months to go to be eligible for a pension, and if I stop before then I lose out. I've got to keep going somehow for that long. After that I can be sick as much as I please. But for the next four months I've got to work right along, like I've always done. Nobody must even suspect I've got anything wrong with me."

"But you can't keep them from suspecting, my dear man. These masses in your neck are bad enough now and they're going to grow faster as time goes on, and you're going to get weaker too. You can't get away with it."

"I've got to. I can't lose my pension and be a burden on my children all the rest of my life."

I had not the heart to say that the rest of his life would probably be short.

"Now, if there was any way you could give me the treatments at night or on Sunday," suggested Pierce hesitantly, "I could go on working daytimes as usual."

My better judgment told me this would not do. There would be reactions; the man would not be able to carry on. Delivering mail in a city meant walking miles every day with a heavy pouch full of letters and magazines. Pierce didn't have his normal strength to start with. There was no use beginning something we couldn't finish.

But we did start and we did finish. Mr. Pierce came to the hospital two evenings a week and on Sunday forenoon. The masses in his neck and axillae and groins melted away. He got out his size fifteen shirts and put them on. He admitted that his appetite was poor but he carried his mail route every day.

When the treatment had been finished, he said good-by to us jubilantly.

"I'll be sending you a payment every week, doctor. And by fall I'll be retired and have my pension free and clear, with no bills hanging over me."

Once more a strange faintheartedness kept me from telling him that he would have to come back for other courses of treatment, from time to time, during the few years he had left. Miss Randolph looked at me in surprise.

"Didn't you tell him?," she asked when he had gone. "It sounded as though he thinks he's cured."

I was embarrassed. It had always been my contention that intelligent people have a right to know what is wrong with them and what their prospects are. But with this man some obscure impulse had made me hold my tongue about the future.

The payments came in regularly as he had promised and in the autumn Pierce appeared at the laboratory one day looking well and very pleased with himself, and dressed in a neat new suit.

"Well, I did it," he announced proudly. "Served my time and kept my record clean. Didn't lose a day's work after you started treatment. Now I'm a man of leisure with nothing to worry about."

At that moment I could not meet Miss Randolph's disapproving eyes but as months went by and Mr. Pierce continued well I regained confidence. I pointed out to her that no disease ever runs entirely true to type, that perhaps it was not always wise to tell people bluntly that they had a fatal disease when one first saw them. I took as much pride in keeping tab on Mr. Pierce as though I had actually been responsible for the strange remission in his disorder and was always glad to have him come in to see us and report how well he felt and how his garden was doing. When summer came again he brought me berries and tomatoes and ears of corn. And finally Miss Randolph concluded that I had not been derelict in my duty to him, as his physician.

"I don't understand it," she said. "I never saw any other case of Hodgkin's act like this. Do you really think he's cured, doctor?"

"No, of course I don't think so. He'll crack up someday, perhaps soon. But in the meantime he's enjoying life much more than he would if I had told him the whole truth to start with. I'm glad I didn't tell him."

Mr. Pierce lived without further treatment or recurrence of symptoms for almost two years. Then, one winter evening, he was brought into the hospital with pneumonia and three days later was dead. McDonald did an autopsy and, although the superficial lymph glands were still only slightly enlarged, he found an enormous mass of swollen nodes in the abdomen. "Maybe he was lucky to go when he did, with this pneumonia," said McDonald slowly. "For his Hodgkin's was about to catch up with him again."

To this day I do not know why this patient should have pursued a course so unusual but the remembrance of it often makes me cautious about brusque diagnosis of incurable diseases. We are all too apt to forget that we deal not with disease alone but with a person also, and that sometimes the patient is the more important of the two.

A Victim of the Cancer Quack

I have had many distressing experiences with the victims of quack cures for cancer but one of them stands out more vividly in my mind than any other.

I first saw Stephen Ghormley after he had come home from a so-called "Cancer Institute." Six months before he had noticed a small sore on his lower lip which would heal over for a few days and then break open again. It was not painful and he might not have noticed it when he did if he had not shaved every day.

"It kinda worried me from the start," he told me. "I've seen things in the papers every now and then and I said to myself, 'This might be a cancer. I'd better keep an eye on it.' "

Unfortunately he had also seen in the papers advertisements of cancer cures—"satisfaction guaranteed or your money back." In an anxious moment he wrote to one of these institutions and from then on was bombarded with pamphlets and form letters.

"I got the wind up after that, and no mistake," he admitted. "It don't take much to convince a fellow who's half persuaded himself."

And so Mr. Ghormley and his wife took what savings they had and went to the ——— Cancer Institute.

"I never saw so many doctors in one place, all of them specialists according to their diplomas. They sure gave me a going-over too. Why the laboratory work they did there amounted to a good deal more than you did on me, here in the hospital."

I had no reason to doubt this. Whatever else these quack "Cancer Institutes" leave undone, they see to it that each patient gets the impression that many complicated and difficult examinations are made of him. Certainly Stephen

Ghormley had faith in these men even after they had put a paste on his lip which ate out a crater nearly an inch wide.

"They kept saying that 'wide destruction' was necessary and for me not to worry. Everything would grow back all right, once the roots of the cancer were all killed."

But that time was slow in coming and when the Ghormleys had used up their ready money the "specialists" suggested that further recovery would go on just as rapidly at home as in the "Institute." And so it was that the couple appeared one day at our cancer clinic in the county hospital.

I noticed them first in the waiting room. Mr. Ghormley had a handkerchief tied around the lower part of his face and his wife sat beside him, bright-eyed with worry. Presently I got them into the examining room where McDonald and Dr. Douglas were waiting. Ghormley's lower lip by this time was practically gone, his lower front teeth were exposed, and we could feel large hard lymph nodes under his jaw.

That morning there began a losing battle. On our side were Douglas, McDonald, a dentist, Miss Randolph, Mrs. Ghormley, the patient, and I. We used radium, we used X rays, we treated the infected teeth and gums. After we implanted radon "seeds" in the diseased lymph glands under the jaw, Dr. Douglas dissected out the nodes en masse. We gave Ghormley tonics, we gave him blood transfusions, we found him a place to live where he and his wife would be warm and dry, we interested charitable people in them so that they had food and clothing. We brought Ghormley to our own hospital for his operation.

But on the other side was a highly malignant cancer which pursued its relentless way in spite of us. After eighteen months Stephen Ghormley died of starvation, with his lower lip and lower jaw completely destroyed.

A Story with a Happier Ending

Ghormley's death was no surprise—he had been unconscious for hours—but still I was startled when I reached the hospital that morning to find that he was actually gone. Somehow he had been with us so long and fought so hard and so bravely for his life, that it seemed impossible to think of him as dead.

Finding that his body was still in the house I went down to look at him once more. In the room I found the undertaker, just arrived. He was a short thick-set man with a callousness of manner which had always annoyed me.

"What was wrong with this fellow?" he asked me.

"The death certificate is in the office upstairs, ready for you," I answered, as I bent over and pulled the sheet away from Ghormley's face.

Instantly I felt a deep silence close around me. It was so oppressive that I glanced up. The undertaker was staring at the corpse with horror-filled eyes.

"My God!," he whispered. "My God! I never saw anything like that before!"

I waited a full minute before saying anything, feeling all the resentment which unnecessary suffering and death arouse.

"This whole thing started with a tiny sore on his lower lip, so small he could hardly see it. It didn't hurt when he touched it. But it wouldn't heal. So he went to a cancer paste quack, and here he is."

The undertaker transferred his stare to me. "You mean that . . . he got into this fix . . . from a little thing like . . . like . . . "

I saw the undertaker's forefinger slowly rise to his own lip and stop there.

". . . a little thing . . . like . . . like this?"

I looked. Just where the pointing finger rested there was a little patch of glistening raw mucous surface. I dropped the sheet back over Ghormley's horribly disfigured face and turned away.

"That's exactly what I mean. You'd better stop, look, and listen if you don't want to go the same way."

Before eleven o'clock that forenoon the undertaker, chastened and subdued, was in my office. At 11:10 I took him down to the laboratory to get McDonald's opinion. At 11:30 he was in the X-ray treatment room.

Eighteen days later he had a patch on his lower lip which looked as though it had been seared with a hot knife blade. Three weeks more and the lip was smooth and soft and perfectly normal again. I wish I could say that the man was permanently purged of his arrogance, but at least he did not die of cancer. What is more, he is still alive and well. That is what radiation can do for cancer of the lip taken in time.

Stop, Look, Listen!

Cancer of the skin—a disease which is plainly visible almost from the moment it begins—kills about 4,000 people in this country every year, at least 85 percent of them unnecessarily. A short course of X-ray and/or radium treatment would cure nearly nine out of ten of these patients. I wish there was some way to get this into the heads of those people who say they would rather not know it if they have cancer or who dread "the knife" so much that they resort to quacks.

I wish too that women would learn to do something about it the very day they first feel a lump in the breast. In the first place many of these lumps are not cancer and are easily dealt with. In the second place, at least three out of four early cancers of the breast will recover if properly treated.

How much wiser it would be to go to a doctor and find out the true state of affairs than to worry in secret over dangers which may not actually exist.

I remember a youngish woman whose mother had had a cancer of the breast, who once came to me in a panic because she had found a lump in her own breast. Certain signs and symptoms—chiefly the fact that the mass was tender to pressure—made me suspect that we were not dealing with cancer, but I told the patient there was only one thing to do: have an incision made and a bit of the tumor removed for McDonald to study under the microscope. This, I explained, should be done in the hospital surgery so that, if the sections showed cancer, operation could be done immediately. It happened that business obligations made it impossible for her to do this at once; therefore we did the next wisest thing—we gave her X-ray treatment over the breast and armpit at night and on Sunday for about a month, for the purpose of preventing the spread of the disease if it were actually malignant. During the course of therapy I became convinced the tumor was not a cancer because it did not shrink. However, as soon as circumstances permitted, the patient came in for her operation. As McDonald and I had both come to suspect the mass was an inflammatory affair and not a cancer, it was not necessary to remove the breast, and the patient went home in three days with a tranquil mind.

Almost as good an outlook can be held out to women with cancer of the cervix (mouth) or body of the uterus. These growths usually give themselves away by bleeding; there are no hemorrhages, merely slight irregular spotting at unexpected times. Many women ignore this apparently trivial occurrence, only to find a few months later that they have a cancer which has already spread into the pelvic organs and become a formidable enemy. If at the first appearance of irregular, untimely bleeding these patients would go for examination, we would have very few death certificates to sign for cancer of the uterus.

Among men, perhaps the commonest readily curable malignancy aside from cancer of the skin is that of the lip. Curiously enough cancer of the lower lip is much more malignant than cancer of the upper lip. However, there is no excuse for any man not bewhiskered failing to know when a growth appears in either location. Prompt treatment with X rays and/or radium will result in permanent cure of some 90 percent of these tumors, whereas the neglected cancer of the lower lip is almost sure to be fatal.

Other Uses for X Rays and Radium

I have already said that radium and X rays are not used solely in the treatment of malignancy. On the contrary, these rays are of great value in many non-cancerous conditions.

Birthmarks

Some babies are unlucky enough to be born with birthmarks, most of which are very disfiguring. Many of these marks can be removed or greatly improved by radiation. Those which respond best are the dark, red, strawberry marks and the thick purplish ones full of blood vessels. More difficult to cure is the port wine stain.

Treatment of these lesions requires great skill and in many cases must be continued for one or two years, but it is surely worth the time and effort if a repulsive blemish can be destroyed. Radium is usually used but sometimes an electric current is preferable and in some cases surgical removal is best. Whatever method is chosen, it is most important to begin treatment early, before the baby is more than a few weeks or months old.

Keloids

Some people, following injury, develop a thick livid scar which is more noticeable than the original injury. This is called a keloid.

There is no known way to prevent a skin so disposed from making these disfiguring scars but X-ray treatment properly done will cause them to disappear.

Acne

Acne is a skin disease which has never cost a life but has caused much heartache. Most of the patients are young people in their teens and twenties and they find that this affliction complicates their social life and their love affairs and sometimes their business careers. It is a much more real bugbear than halitosis or B.O. One occasionally hears older people who should know better say to each other, "I wonder if so-and-so's boy has syphilis; his face is so terribly broken out."

To assure these unhappy young people that the disease will probably die away after thirty is of no use, for to them everyone over thirty is in his dotage. But a competent radiologist can do much for them. The skin lesions of acne clear up rapidly under small doses of low-voltage X rays.

But one precaution must be taken without fail: acne is an essentially chronic condition which is sure to recur at intervals during a period of several years, and therefore X rays must be used with care. If they are given over and over, without caution, they may themselves produce changes in the skin which are as bad or worse than the acne.

Therefore the young man or woman with acne should consult first a skin specialist and follow his advice conscientiously throughout the year, reporting for X-ray treatment by a well trained radiologist when the lesions fail to respond to other measures. In addition, such a person should keep in his possession a record of the amount of radiation he has had and the dates on which treatment was given. If he will do this, he will be in no danger of entering middle life with a skin doubly disfigured—by acne and by radiation damage.

Warts

I remember a boy I went to school with who boasted that he had counted 125 warts on his right hand and 70 on his left. But most people are not proud of having warts, and some of these growths are large enough or numerous enough to be very annoying.

In my childhood I saw old men put darning needles through warts and then hold them over a lighted lamp while the needle grew red-hot and seared the wart. I have also seen warts eaten off piecemeal by the application of caustic acids.

It is much simpler, as well as painless, to have these growths removed with low-voltage X rays. This treatment is successful in about two cases out of three; should it fail, the patient can always have the wart removed by a surgeon.

Tuberculous glands

Now that milk is generally pasteurized and dairy cows tested for tuberculosis we see comparatively little scrofula but in my childhood it was not at all uncommon to find in any small town several youngsters who lost many weeks from school every year or two while they had the swollen tuberculous glands in their necks operated on. Usually a series of operations was necessary and by the time the child grew up he had a badly scarred neck.

Today we see only a few such cases and when we do find them we treat them with X rays or ultraviolet rays or sun baths or all three in turn. The glands return to normal in most instances without breaking down, and the child recovers much more promptly than he did with surgery and without disfiguring scars.

Erysipelas

Erysipelas used to be greatly dreaded in hospitals and among elderly people suffering from debilitating chronic diseases. But it is now treated with great success with the sulfonamide drugs.

X rays also will control erysipelas. The treatment requires only a low-voltage machine, seldom has to be repeated more than once or twice. In most cases fever falls and rapid improvement appears within twenty-four hours.

Boils and carbuncles

Boils are painful and carbuncles, being deeper seated than boils, are often dangerous. Boils treated with X rays within twenty-four hours after they begin to develop usually clear up gradually without being opened. Carbuncles require heavier treatment than boils but often respond almost as well.

Infections around the face are difficult to treat surgically because of the danger of permanent scarring, and infections around the nose may lead to meningitis and death. Many of these conditions can be cured with the sulfonamide drugs, but X-ray treatment—using small repeated doses of medium-voltage rays—is also of great value.

Athlete's foot

This is the popular name for ringworm of the feet. It is a chronic fungus infection of the skin which is as difficult to cure as it is annoying. Sometimes every form of treatment fails. But in a good many cases small divided doses of X rays (at low voltage) give great improvement. Combined with wet dressings such treatment is very useful in the acute stage. But here as in other diseases of the skin, X-ray treatment must be used expertly if the end results are not to be worse than the disease itself.

Bronchiectasis

There is a very distressing chronic infection of the lungs known as bronchiectasis which X-ray treatment often helps. This condition is primarily an infection of the bronchial tubes. In children it often develops following pneumonia, measles, repeated colds, and tonsil infections. It also appears in many adults who have persistent sinus infection.

The patients have a cough which comes on at more or less regular intervals during the day and in paroxysms; they often raise large amounts (one or two quarts) of sputum a day; they are subject to recurring attacks of pneumonia; and in many cases the odor of their expectoration is so foul that all social life is impossible.

The medical treatment of this disease has always been unsatisfactory. Surgical treatment means the removal of a lobe of the infected lung or perhaps of a whole lung; this requires a surgeon of exceptional skill and long training. Therefore the rather recent development of a technique of X-ray treatment which produces marked improvement in these patients is a real achievement. They are not cured, it is true; but 60 to 80 per cent of them show great improvement. They cough less and raise much less sputum, they gain weight, they have fewer bouts of pneumonia, and frequently the foul odor of the expectoration disappears.

Fibroids

Many women in middle life develop a uterine tumor known as a fibroid. It is not a malignant growth (except in very rare instances) and does not spread into other parts of the body. But some fibroids grow very large and many of them cause so much bleeding that the patient becomes anemic.

Women still in the childbearing period are usually advised to have these growths removed surgically; complete recovery is the rule.

Older women and those in whom surgery is contraindicated for some reason (e.g. heart disease) can be treated successfully with X rays. Here too permanent recovery is to be expected. Most of these patients can go about their usual occupations while being treated.

CHAPTER XII

How Radiation Acts

X RAYS are man-made and their powers of penetration depend on the electrical voltage at which they are generated, while radium continuously and spontaneously gives off its gamma (γ) rays which have astonishing penetrating power. But essentially the two types of radiation are the same. (The less powerful beta (β) rays emitted by radium are used to treat only a few superficial conditions.)

This means that, in treatment of disease, radium and X rays are largely interchangeable. Which is to be used depends, largely, on which is more easily available, on the technique required, on the sort of case, and on the experience of the radiologist. For instance, it is easy to insert radium containers into the mouth and nose and to employ X rays on the surface of the body. Radium packs can be applied to surface disease and radium bombs containing large amounts of radium can be used in the same manner as X rays, to be sure, but this demands a large supply of radium and is therefore too expensive for many small clinics and hospitals.

The important thing to remember is that radium's gamma (γ) rays and X rays are first cousins, and that the higher the voltage at which X rays are generated the more like their relatives they become.

Like most discoverers roentgenologists followed the trial-and-error method with X rays for a considerable period.

By 1900 they had learned in this way that these rays caused reactions in the skin and often produced marked improvement in tuberculosis of the skin (lupus), so they went on to attack many diseases with an enthusiasm unmarred by any inkling of the disillusionment which awaited them.

They had, it is true, a measure of early success—as, for example, when Senn found that leukemia, that stubborn blood disease, improved after X-ray exposures—but many disquieting things occurred. Thus radiologists saw the skin of their own hands breaking down in chronic ulcerating sores which slowly turned into cancer, they watched their patients' hair fall out, they found that a dose of X rays too light to damage the skin visibly could produce permanent sterility. But in spite of this evidence that they sometimes harmed their patients and themselves, they persisted in trying X rays and radium on all manner of ailments. To the ardor of these early students we owe a great deal we can never repay.

But gradually, accumulated experience proved that tuberculosis of the lungs did not respond to radiation, that cancer although it improved for a time later recurred, that the aftermath of treatment was often as bad as the original condition itself. There followed a period of pessimism when the fickle dropped out, leaving the field to a handful of men who realized that they could never employ radium or X rays successfully until they understood the effects of radiation on living cells and tissues and had worked out a method of measuring doses accurately.

Confronted by disbelief and hostile criticism, these doctors discarded the hit-and-miss methods of early years and searched for facts on which to base more solid achievements. One of the things they learned was that X rays and radium have more effect on young growing cells than on mature cells, on the cells of tumors than on the cells of adjacent normal tissue. Radiation might be compared to a weapon which killed off the crooks and the boys and girls but spared the honest, the elderly, and the middle-aged. Quite naturally, after this was discovered, some radiologists conceived the idea of knocking out the cancer with a single huge dose of X rays.

This "massive dose technique" was practiced for years, especially in central Europe where it survived in modified form into the late thirties. (What has happened to radiation under Hitler's *New Order,* only his phony Nordic gods can tell!) The trouble was that this type of treatment was almost as much of a knockout for the patient as for the tumor: reactions were severe and much harm was often done the normal tissues near the cancer. I remember very well cases I saw when I was in medical school and how "radiation sickness" was dreaded by doctor and patient alike.

During the second decade of this century a swing away from the massive dose began and during the twenties it gained momentum. The large single dose was replaced by the "fractional" and "saturation" methods, in which smaller doses are given at intervals of one to four or five days. In this way the radiologist can reduce the harm done to healthy tissues and still increase the total amount of radiation delivered to the tumor area. Only in the treatment of isolated lesions on the skin or lip is the massive single-dose technique now practiced.

While this was going on, a handful of men here and there were studying radium and devising ways of using it. By the time World War I came along they had pretty well demonstrated the value of the new element as well as the technical difficulties of applying it. During this period several institutions in the United States bought their first stocks of radium and practical research began in this country also.

It can honestly be said that the successful treatment of cancer with radium and X rays is based on research done between 1895 and 1918 and was brought into general use in the twenty-five years after the First World War.

What May Happen to the Radiologist

Most radiologists have to learn at first hand the danger they face in handling radium and X rays. Some years ago, when I was taking special training in radium therapy, I had such an experience.

One busy afternoon a tiny tube of radium disappeared from the room where four of us were making up applicators to be used that night. (Radium works as well in the dark as in daytime.) We searched for it earnestly but could not find it, so we called on the physics department to continue the hunt. After a day or two the physicists reported that they could find no trace of it in the hospital incinerator or rubbish, and thereafter the matter was put down as an unsolvable mystery.

But one morning about three weeks later a young doctor who had been working in the preparation room when the radium disappeared showed us a red spot on his ankle. "Looks like a radium reaction to me," he said. "I guess I'd better ask the chief what he thinks."

The chief agreed with this opinion and added a suggestion of his own. "If I were you, I'd go through my clothes and see what I could find."

The young doctor did so and in the cuff of a pair of trousers discovered the missing tube of radium.

Another experience, this time of my own, taught me something else. I had taken a job which entailed examining a great many patients for stomach or intestinal disorders. This meant spending a good deal of time in the fluoroscopic room, but I enjoyed the work and had no thought of possible evil effects. But as time went on I began to feel seedier and seedier: the energy I had always had so abundantly failed me and getting out of bed in the morning became a terrible task.

After three or four months of this a colleague of mine discovered that I had a severe anemia. In searching for the cause I found that an improperly built machine had been giving my long bones (where blood cells are manufactured) a heavy dose of X rays every time I examined a patient with the fluoroscope. During the slow-passing weeks it took me to recover I pondered more seriously than ever before the uncanny business of radioactivity and all it means.

Sensitivity to Radiation

Different sorts of cells have different degrees of sensitivity to radiation. In general, tumor cells are more sensitive than the cells of normal tissues. That makes it possible to give many growths enough radiation to destroy them without at the same time destroying near-by healthy organs. But tumors vary among themselves in sensitivity. Here also, however, there is a general rule: tumors composed of immature, rapidly growing cells are more easily destroyed than those whose cells are older and tougher and more resistant.

If we have some idea of the comparative sensitivity of different tumors we can deduce with reasonable accuracy whether radiation is or is not advisable in an individual case. The pathologist helps us in this respect when he reports the degree of malignancy of a tumor. My friend, McDonald, can see things about cells when he studies them under the microscope which indicate to him how dangerous the growth probably is. He insists that this "grading" of malignancy is by no means infallible, but I notice that the surgeons who take his advice do better than those who ignore him. He usually suggests relying on surgery for the localized and less malignant types of tumor and combining operation with radiation for the more dangerous sorts, especially those which have already begun to metastasize.

The idea back of this is a simple one: it is better to hit an enemy as hard as possible the first time than to tap him gently on the head at intervals for several hours, better to attack a menacing disease with two weapons simultaneously than with one alone.

We know that a heavy enough dose of either X rays or radium will destroy any cancer. The problem is to give an adequate amount of radiation without doing the patient's normal organs irreparable damage. And that is not easy; in fact it is sometimes impossible. But by combining surgery and radiation we can in many cases destroy the tumor without harming the patient permanently. It is not too much to say that more than half the cancer cases today could be cured if we could only get them under treatment before the disease had invaded other parts of the body.

Reactions to Radiation

To be sure, patients have reactions to radiation therapy. But with competent radiologists these reactions are no longer serious.

To begin with, some ten or twelve days after treatment is started the patient will notice slight reddening of the skin over the areas irradiated. This redness will gradually increase, reaching its maximum about the twenty-first day (or later, in the case of prolonged treatment). There is no pain and no blistering, but there is more or less scaliness of the skin for a time and there may also be a fairly heavy tanning for several months. The commonly used term

"X-ray burn" is a misnomer. With modern methods we do not get destructive skin reactions except when we deliberately use massive single doses of radiation on small superficial growths; then, it is true, we see intense reactions, but, since they involve only a small area, they clear up without permanent damage or disfigurement.

Some years ago most of our patients had disagreeable general reactions to radiation therapy but this too is now unusual. Now and then someone will tell us that he is nauseated or has a poor appetite or an upset stomach, but many people continue their usual routine of life and work during the whole course of treatment.

CHAPTER XIII

Something about Radium for Those who Are Not Gun-shy of All Technicalities

WHAT IS RADIOACTIVITY?

THE Curies discovered radium in 1898. Two years later, at McGill University (in Canada), a pair of young British scientists named Rutherford and Soddy made a startling discovery of their own about this strange new element: that it is the halfway house in the spontaneous evolution of uranium into lead.

For centuries men had been seeking a way to turn base metals into gold and, ironically enough, it now appeared that they had all the while been walking around over an alchemy which was constantly transforming uranium into lead in the ground beneath their feet. This process goes on slowly, soundlessly, inexorably; we can neither hasten it nor delay it. In the course of a few million years, when uranium after passing through many intermediate stages has at last turned into lead, it apparently stops itself.

This transformation takes place inside the atom. The uranium atom, as atoms go, is very large; it possesses great latent energy and an apparently unbounded hankering for change. This change it achieves by ejecting bodily certain radiant particles.

Alpha, Beta, and Gamma Rays

The first to be discovered of the radiant particles which the radioactive atom throws out was that which the French scientist Becquerel stumbled upon when he found that a piece of uranium placed on a sensitized plate would photograph itself. The power to do this arises from the fact that the uranium atom constantly ejects particles called beta (β) rays. These rays really consist of streams of negatively charged electrons moving somewhat less rapidly than visible light.

It was Rutherford and Soddy who found that radium emitted not only beta (β) rays but also a second set of particles which they named the alpha (α) rays. Alpha (α) rays are larger and more energetic in some ways than beta (β) rays, but they are less speedy and they carry a positive charge. Eventually they were proved to be footloose, homeless nuclei of helium atoms.

Finally, Rutherford and Soddy discovered still a third form of energy given out by radium which they christened gamma (γ) rays. These are really super-X rays, cousins thrice-removed of ordinary light, which travel at the same unimaginable speed as visible light (seven times around the earth per second) and have extraordinary powers of penetration.

Through the spontaneous and constant emission of these three types of rays radioactivity manifests itself and slowly transforms uranium into lead. The sluggishness of this process is astounding. Compared with the career of some of the radioactive elements, human life is momentary. Contrast, for example, the sixty-three year life expectancy of the American today with the average life of radium which is twenty-three hundred years.

Life-Period of Radium

Radioactive elements disintegrate, physicists tell us, according to an exponential equation. The easiest way to think of this is to visualize a man with a cube of butter on a table in front of him. If he cuts it in two, he still has half of it left. If he cuts off half of that, he still has one-fourth of what he started with. Then he can cut off half of that, and so on and so on; theoretically he will always have at hand half as much as before the last previous division, although practically he will soon possess too little to butter his bread.

And so it is with radium. Suppose one had started the present era with a gram of radium in his possession; in 1600 A.D. half of it would have been well on its way to becoming lead and the other half would still have been present and accounted for. Or put it another way: if a forward-looking Roman in the year 7 A.D. could have invested in a quantity of radium, his descendants coming to Virginia with Captain John Smith in 1607 would have had half of it left and their descendants in 3207 would still be able to bequeath to their heirs a quarter of the original amount.

Radium Rays Used in Medicine

Two of the three types of radiation emitted by radium are used in medicine today—the beta (β) and gamma (γ) rays.

Beta (β) rays have a caustic action; they destroy skin and flesh and, when employed carelessly or ignorantly, produce chronic ulcerations. But since they have little power of penetration, they must be used to treat disease on or near the surface of the body.

The super-X rays called gamma (γ) rays, on the other hand, have no such caustic effects and do comparatively little damage to the skin. Their action consists, rather, of an indirect slow destruction of the cells they pass through. But their ability to penetrate is astounding: in order to prevent the escape of these rays in amounts sufficient to menace the health of patients and staff alike, hospitals must keep their radium in lead-lined vaults just as they must surround their high-voltage X-ray tubes with the same heavy metal.

Radium Emanation (Radon)

Early students of radium found that it gave off a gas which possessed many of the radioactive powers of the parent element. This gas, called radium emanation or radon, will collect on objects exposed to it and render them temporarily radioactive also.

Radon preparations have indeed all the qualities of radium except long life. They emit alpha (α), beta (β), and gamma (γ) rays but lose half their potency in four days and by the end of a month are almost inert. During that month, however, they are as useful as radium itself and this fact gives them great medical value.

By using radon it is possible to make a small amount of radium do a great deal of work. First of all, the supply of radium is dissolved in a dilute acid solution and put into a flask which is stored in a lead-lined safe. The gaseous emanation given off by the radium is then pumped out of the flask into a fine capillary tube of gold no thicker than a hypodermic needle. This tubing can be cut into sections of any desired length and the ends of these sections sealed with a flame. These bits of gold tubing can then be used instead of tubes of radium proper. Furthermore, while the radon is in use, the stock of radium is producing more emanation for the future. In this way many more patients can be treated at one time than when we must depend on the element alone.

How Radium Is Prepared

There have been many changes in the ways of handling radium since the day when Henri Becquerel carried it in his vest pocket and Pierre Curie taped it to his forearm. We have now, for instance, many different types of radium applicator.

One variety is the flat plaque an inch or less in diameter, which has been coated with a thin layer of varnish, enamel, or glass with which radium has been mixed. These plaques are used to treat surface lesions with which they can be held in contact by means of a long handle. The skin specialist (dermatologist) finds them useful in a number of skin disorders but if he does not use them skillfully they are extremely dangerous.

More often we employ radium encased in hollow tubes or needles of steel, gold, or platinum. The walls of these tubes are only about two to four times as thick as a sheet of ordinary writing paper. Radium needles are pointed at one end and have a hole in the other through which we can put a tough thread before using them; then if we can see the threads we know where the needles are.

The tubes vary in size a good deal but are seldom over an inch long. They have small projections at one end into which holes are drilled for threads. If a bunch of tubes are put together into a pack we gather these threads into a little cable and stick them to the patient's skin with adhesive.

Either tubes or needles can be grouped to form a "pack." They may be stuck to sheets of lead or plastic material; they may be fastened to blocks of light balsa wood; they may be thrust into the center of rolls of bandage or gauze.

Then the whole assembly is made into an applicator of a size and shape to fit the surface of the patient's body at the site of treatment.

Small tubes and needles can also be put into a long slender tubular applicator which can be introduced into the vagina or uterus or rectum.

Or one can treat a tumor directly by inserting containers into the growth itself. Needles can be used but must be subsequently removed, while very short bits of gold tubing containing the gaseous emanation of radium (radon) can be pushed through the skin into the desired position and left there. (Radon soon loses its radioactivity and becomes inert, and the gold "seeds" being sterilized before use are harmless.) In this way we can irradiate large growths difficult to treat adequately from the surface and certain inaccessible tumors such as those deep in the neck or in a bronchial tube. I suppose there is no radiologist alive who treats cancer who has not, like myself, spent a good many evenings cutting up potatoes and similar objects into the shape and dimensions of the tumor he is about to attack and practicing the angles and depths at which he must deposit his radon "seeds" in order to insure a uniform dose of radiation where it is needed.

Losing Radium

For all our precautions in fastening radium tubes to the patient's skin, these tubes are sometimes lost. A man I know had a harrowing experience of that sort very soon after investing most of a year's net income in a supply of radium.

He was treating a woman for a growth in her nose. Somehow the strings attached to the radium capsule came loose from the adhesive fastening them to her cheek and when she drew a long breath the tube slipped its moorings and slid down her throat. Since it was first of all necessary to find out whether she had swallowed or inhaled the radium container, my friend rushed her to the fluoroscopic room. When he saw the metal capsule in her stomach he was relieved for there was a chance that it might work its way through her intestine whereas, had it been in her lung, it would have had to be removed at once through the bronchoscope.

All day, at intervals of an hour or so, he screened her abdomen to make sure the radium was moving along. By evening it had reached the cecum (the blind end of the large bowel, near the appendix). Three successive observations showed it in the same position. Then my friend called a surgeon in consultation. After another hour's wait they operated and removed the capsule. Had they not done this, the radium would probably have done irreparable damage to the wall of the intestine against which it lay.

As it was, the woman made an uneventful recovery and later resumed her radium treatment. But this time my friend was not content to stick his anchor cable to her cheek with adhesive. He twisted all his threads together securely and sewed them to the lady's nightdress. Then, if she had swallowed the capsule again, the nightgown would have gone down with it.

CHAPTER XIV

Using X Rays and Radium Safely

Now that I have said so much about the power of X rays and radium to destroy both tumor cells and normal flesh, it must be clear that patient and physician alike need protection from these rays. This might seem impossible at first thought but it is not, although it does demand constant watchfulness as well as precision of technique.

DISTANCE

One very effective method of protecting oneself from the rays given out by X-ray tubes and radium is to keep a respectful distance from the source of the radiation. This is because of the "inverse square law," according to which doubling the distance from the X-ray tube quarters the amount of radiation falling on any given area. Or, put it this way: if one tube of radium is placed one inch from the skin and another tube of exactly the same size and strength is placed two inches from the skin, the dose of radiation in the two cases will stand in the proportion of two squared (2^2) to one squared (1^2), or four to one. That is, when the radium is only one inch from the skin the dose delivered will be four times greater than when it is two inches distant.

This rule applies to the beta (β) and gamma (γ) rays of radium, to X rays, to ultraviolet, and to ordinary light.

Now it is easier to maintain long distances between the X-ray tube and the patient—indeed the tendency of modern technique is to increase this distance—than to do so with radium. Obviously neither physician, nurse, nor patient can sit hour after hour holding a radium applicator in a certain position at a specified distance from the body. But we can make a cast of the part of the body to be treated out of dental compound, embed in it radium tubes or needles, and bandage the whole cast on the area under treatment.

Or we can mold to the contours of the body a warm mixture of wax and paraffin and, before it cools, bury in it tubes of radium or stick them on the surface of the wax with adhesive, and then apply the mold to the patient. We can also use blocks of light balsa wood grooved to hold tubes of radium or radon, or slip capsules of radium wrapped in layer after layer of gauze into the center of a roll of bandage which can then be stuck to the skin with adhesive tape.

Nearly every new case presents new mechanical problems to the radiologist. To solve these problems and at the same time achieve safety and effective treatment demands, over and over, a man clever with his hands. But sometimes it is the patient who displays the ingenuity.

I once treated for superficial cancer a man whom I knew to be thoroughly reliable and intelligent. When therefore, one afternoon, he asked to leave the department with the radium applicator in position to go to a movie, I consented, telling him only to be back by three o'clock so that we could get the radium off at the proper time.

We were busy that day and not until Miss Randolph called my attention to the clock did I realize that it was 3:30 and the patient had not turned up. At the same moment I realized that I did not know which theater he had gone to. One by one I called the movie houses, but to no purpose. Finally at ten minutes to five, our man walked in.

"Good Lord," I exclaimed, "where have you been?"

He named a small rerun house I had not thought of. "Lots cheaper to see pictures the third time they come along," he observed judicially.

"Damn the pictures!" I cried. "You've had that radium on nearly two hours longer than you should."

"Oh, no, I haven't, doctor." And with this the patient unrolled his umbrella and handed me the radium applicator intact.

"You see, I didn't get in at the beginning of the feature and I wanted to see it all. So I watched the time and at ten minutes of three I went to the washroom, took it off, dropped it into my umbrella and rolled it up there. Then I sat down on the side aisle where I could lay the umbrella down along the wall three or four feet away from me and still watch it and make sure no one else got near it."

Here was a man who had learned to use distance to protect himself and other people.

Filtering X Rays and Radium

But distance is not the only way to insure safety in using radium and X rays. We also filter the rays. Most modern X-ray machines have thin sheets of aluminum, zinc, or copper permanently fastened into the tube assembly. Then, of necessity, all radiation reaching the patient must first pass through a certain known thickness of one of these metals; in this process it loses those rays which have the most caustic effect.

We use metal to filter radium also. Only the plaque is without filtration. Radium salts or radon, being used in very small quantities can be put into hollow needles or tubes made of steel or gold or platinum without making these tubes much larger than the lead in an ordinary pencil. If need be, a cluster of such tubes or needles can be slipped inside a metal capsule, thus preventing loss and increasing the filtration.

In this there is one complication which the radiologist must deal with: gamma rays in passing through the walls of these needles and tubes stir up secondary beta rays in the metal itself, which are capable of causing tissue destruction. To get rid of this undesirable radiation we cover our capsules of radium or radon with a thin layer of vulcanizing rubber or slip them into thin-walled jackets of aluminum—an element so light that, even under the bombardment of gamma rays, it emits only very feeble beta rays.

Treating Surface Lesions

The easiest tumors to treat are naturally those on or near the surface of the body; here it is possible to localize the dose of radiation and therefore to keep the reaction in adjacent normal tissues at a minimum, and it is also possible to deliver in the growth itself a high percentage of the total radiation falling on the skin. Under these conditions one can often administer a single dose large enough to destroy the tumor entirely or, failing this, to give a number of moderately large doses close together with cumulative effects. For these reasons treatment of such conditions as cancer of the skin should, in competent hands, result in permanent cure ninety-five times out of one hundred.

Cross-Firing

On the other hand treatment of tumors deep-seated in the body and surrounded by normal organs of equal or nearly equal sensitivity is more difficult. In such cases we re the technique known as "cross-firing."

This consists of aiming a beam of radiation from each of several different angles in such a way that they all intersect in or near the growth. Only so can we deliver to the lesion an amount of radiation greater than that falling on any single area of the skin surface.

This makes possible heavy radiation of a cancer without doing permanent damage to the skin. Such measures are required in abdominal cancer involving the kidney, bowel, or stomach, in cancer of the breast, especially when the lymph glands near the shoulder and armpit (axilla) are involved, and in cancer of the pelvic organs. In skillful hands it is very effective. But it is essential that the plan of treatment be worked out carefully beforehand and that the doses of radiation be accurately measured and recorded as they are given.

Inside the X-ray Laboratory

With so much emphasis on the necessity of protection against X rays and radium, anyone might be forgiven for thinking that the radiological laboratory must be a place of horrors. But it is not.

If you came to our department at the hospital to watch an X-ray treatment being given, you would see nothing terrifying. Quite the contrary. There is almost no noise. No electric sparks flash about overhead, everything moves smoothly and quietly.

After removing his outer clothing, the patient goes with Miss Randolph and me into a small bare room where he lies down on a table which stands in the middle of the floor. Down from the ceiling projects a boxlike shaft through which the invisible rays emerge. We pump up the table, like a barber chair, until the patient's skin is at the desired distance from the source of the rays and mark out on it the fields to be treated, bordering them with sheets of lead or lead-rubber which protect the adjacent skin. Then we turn on the ventilating system, look to see that the filters are in place, and go out, closing the door tightly behind us.

The generating machinery and the tube are in a separate room whose thick concrete walls protect both patient and operator from stray radiation. During the treatment Miss Randolph sits in a booth from which she can look through one window of lead glass at the patient and through another at the apparatus. At her right is an instrument panel covered with indicators, dials, meters, and switches by means of which she selects the voltage and amount of current to be sent through the tube. There is also a device which measures, minute by minute, the quantity of radiation received on the surface of the patient's body.

While a treatment is going on Miss Randolph never leaves her post; she not only adjusts the apparatus from time to time and watches the patient but also records on a chart the date, the patient's name, the diagnosis, the number and size and location of the areas being treated, the electrical settings of the machine, and the dose of radiation given. When the time is up, she turns off the current, throws out the main switch, opens the treatment room, and helps the patient off the table. He has heard nothing, felt nothing. In fact a good many of our patients cat nap during their treatments. Most city bedrooms are far noisier and more uncomfortable than the treatment room. To a visitor expecting the horrendous it must all seem very drab and uninteresting.

Of course older machines were not so quiet and convenient. The model with which I first gave high voltage X-ray therapy had a mechanical rectifier which roared menacingly behind a partition made partly of glass and a spark gap, just above the patient's head, across which the electric current jumped whenever there was a surge in the line voltage. I always had to explain all these noises to nervous people and assure them that the roaring and crackling were harmless and incidental.

In those days the X-ray tube was housed in a metal cylinder some seven or eight feet long and perhaps three in diameter; this cylinder sometimes hung from the ceiling on stout supports and sometimes stood on legs on the floor. Together with the tube it could be rotated and tilted so as to direct the beam of X rays in several different directions. Electric current was brought in over brass tubing mounted on insulators a foot or so beneath the ceiling and was carried to the tube over heavily insulated cables or wires.

The operator sat in a booth outside the treatment room with the control stand in front of him, keeping one eye on his meters and switches and one on the lead-glass window through which he could see the patient. With these older machines treatments took longer than they do now and I formed the habit of holding up as many fingers as there were minutes left to go whenever I caught the patient's eye upon me. We had no ventilating systems then and the odor of the ozone set free by the high voltage current combined with the noise of the apparatus to keep our patients on tenterhooks. But, crude though this equipment might seem today, we cured people then just as we cure them now—though not, perhaps, so comfortably or quickly.

The lower voltage machines used in treating superficial growths are smaller and require less elaborate protective devices than the million-volt apparatus. They too operate almost noiselessly. But it is just as essential with them as with the more powerful equipment to be accurate about time and distance and filters, and the size and position of the fields treated, because it is even easier to damage the skin with lower voltage X rays than with super-voltage rays. For that reason Miss Randolph and I have an unwritten pact that each will check the other's filters when we are giving low-voltage therapy. Having never yet been hauled into court for malpractice on the ground of injuring a patient during treatment, I never want to be.

An observant visitor in our department would notice that most of our patients get radiation over more than one field at a sitting and that they are often turned into different positions. This is the technique of "cross-firing" already mentioned, by means of which we deliver a heavier dose to a deep-seated lesion than to any one area on the skin.

For example, if we are treating a tumor in the middle of the pelvis, we direct a beam of X rays from each of four or five different angles so that they will intersect in or near the growth; it will then be more thoroughly and uniformly irradiated than if we used only one portal of entry. In "cross-firing" we must be careful that the treatment fields do not overlap; if they should do so, the overlapping areas on the skin would get an overdose with disastrous results. That is why we mark out the patient's skin with dyes and place our sheets of lead or lead-rubber so accurately before beginning each treatment.

Except when we are dealing with a small surface lesion, we give our patients a series of treatments. Sometimes these come every day, sometimes two or three times a week. But before we start treatment we decide on the total dose to be given and schedule the entire course from the beginning. Usually a series requires from one to four weeks, but the amount of radiation needed varies with the type of tumor, the location of the lesions, and the stage to which the disease has advanced.

A Glimpse of Radium Treatment

So far as the onlooker is concerned, radium therapy is still less spectacular than X-ray treatment. Here there is nothing whatever to hear and little to see.

First of all comes the room in which we make up our applicators. At one end is the safe—its lead sheathing hidden—where we keep our radium and radon. Along one side wall there is a chart by means of which we calculate the strength of the tubes of radon on hand. (You remember its radioactivity declines progressively and disappears altogether in some forty days, which means that it is not the same today as it was yesterday or will be tomorrow.) Along the other side is a counter at which we work. It is covered with a thin sheet of lead, and along the front of it there is an upright board faced with lead to keep tubes and needles from rolling off. At the top of this upright board a panel of lead glass is mounted at an angle of forty-five degrees, so that it extends over the counter. We stand behind this panel, with our arms around it at either end, and look down through the glass at what our hands are doing on the workbench. We always pick up the tubes and needles of radium or radon with long forceps and as soon as we finish making up an applicator we drop it into a lead-lined container until it is taken to the patient's room.

People who are receiving radium treatment feel nothing at all unless the applicator causes discomfort. This sometimes is unavoidable, as for instance when strips of lead with capsules of radium attached are put into the mouth and kept there for several hours or when radium applicators are introduced into the uterus or rectum. But for the most part our patients lie in bed or sit about the department during their treatment, feeling no sensations whatever.

Measuring the Dose of Radiation

The dosage of X rays is measured by a delicate apparatus (known as an ionization chamber) and carefully checked, because no two X ray tubes ever emit the same amount of radiation per minute. But the dosage of radium is easy to calculate because a given quantity of radium always gives off a definite and unvarying amount of beta and gamma rays each minute. We express this dosage simply, in terms of milligram hours (the product of the number of milligrams of radium multiplied by the number of hours it is used). Thus, 100 milligrams of radium applied for one hour gives a dose of 100 milligram-hours, and 50 milligrams applied for 24 hours gives a dose of 1200 milligram-hours.

The unit of measuring X rays is known as "r"; it is an arbitrary amount of x-radiation adopted by the international society of radiologists. It is read off directly on the instrument called the ionization chamber or r-meter, which is kept in place while treatment is going on.

The quantity of radiation required to destroy the various types of disease, malignant and nonmalignant, in which radium and X rays are used, has been worked out quite accurately, so that there is no reason for overdosage. The total dose of radiation needed is calculated before treatment begins and the entire course carefully planned from the start. There is no longer anything hit-or-miss about the radiologist's work.

Protection of Laboratory Personnel

Having heard of the evil effects of X rays and radium, many people wonder how those of us who spend our working lives in radiological laboratories protect ourselves from these mysterious rays. The fact is that we have not always been able to do so.

To begin with, no one knew that either radium or X rays was dangerous. Of course the men who did the early research noticed that the skin on their hands turned red after exposure, but it was several years before any of them began to develop cancer. And even then it was not certain that the radiation had produced the disease. By the time the danger was recognized the damage done was irreparable and one pioneer in radiation after another died of cancer caused by repeated exposure.

But slowly roentgenologists learned to wear lead-rubber gloves on their hands and to keep their distance from the X-ray tube in operation, to cover their patients' skin with sheets of lead or lead-rubber during treatment. Slowly the manufacturing companies learned to build protection into their X-ray machinery, to enclose tubes in lead-glass bowls and to put lead shields along the sides of the tables. Radiologists learned not to dawdle at their tasks, never to pick up a radium or radon container bare-handed, always to use long forceps in arranging radium applicators, to keep all radium and radon not in use in lead-lined safes and to transport these elements from place to place in lead-lined boxes carried at a respectful distance or pushed about on long-handled carts.

Now there are well-defined standards for the protection of the men and women who work with radium and X rays as well as for their patients. For instance, we know the limit of radiation a normal adult can take week after week without harm. Instead of putting X-ray and radium departments in dark basements we insist on good ventilation and proper space. We never stand in the way of a direct beam of X rays and never get closer to the tube than necessary. In using the fluoroscope we do not put our hands behind the patient but keep his body between us and the tube. (After all he is exposed but once while we are exposed every day.) We prevent electric shocks by seeing that our machines are properly grounded and the high-tension tubing at least nine feet above the floor.

Most new appartus is now shockproof and the equipment for bedside work is almost foolproof. I began X-ray work in the era when portable machines were still a nightmare. By the time everything was ready for the exposure to be made, the air above the patient's bed was a maze of dangling bare wires any one of which was capable of giving one a thundering jolt. The fact that hospital beds are usually metal only added to the hazard. Sometimes even today I wonder if I am dreaming when we push our portable bedside unit into a patient's room, move it around under or over him or put it in the bed with him if we wish, in full certainty that neither he nor we will be knocked over by an electric shock.

Employees in radiological laboratories should not work more than thirty-five hours a week (although they often do) and they need four weeks vacation a year (though they do not always get it). In order to check up on the exposure we cannot entirely escape, we stick a dental film on our clothes occasionally and see whether we can wear it a week without blackening it too much; if after it is developed we can read newsprint through it, we are within limits of safety. And every six months I see to it that Miss Randolph and Miss Abbott and Miss Fairfax each have a general examination and a blood study. Having had my own experience with X-ray produced anemia I do not want any of my assistants to develop such a reaction.

Our present treatment room is lined with lead six inches thick. If and when the hospital puts in a new million-volt machine, the room housing the generator will have a concrete floor thirty-six inches and concrete walls from eighteen to twenty-four inches thick. Also the window through which the operator will observe his apparatus will consist of a tank holding a layer of water ten inches thick, one side of which will be a two-inch sheet of lead-glass.

Our supply of radium is now kept behind ten inches of lead and the room in which we make up our applicators is used for nothing else. On the work-bench there is a collection of long forceps for picking up the tubes and needles, and between the body of the technician and the radium she is handling there always stands a screen of lead. We carry our radium to the patients' rooms in long-handled boxes exactly like those in which the elders took up the collection in the country church I attended as a child. And if we are using a large amount of radium, none of us stays in the room while treatment is going on.

There are some who think all these precautions are absurd. I have quarreled with some doctors when they have demanded that I exceed the limits of safety, even though they ranked higher than I on the hospital staff. It is only fair to add that most of them were not radiologists or even recent graduates in medicine.

In 1941 the Mayo Clinic reported that, in the preceding twenty years, 135 physicians had been examined at the clinic because of radiation injuries. Of the 135 only 8 had had any special training in the use of radium and X rays. Of the remaining 127, 91 had been injured while reducing fractures under the fluoroscope. Seventy-eight of the 91 had taken no precautions to protect themselves. The next greatest number (21) were injured while examining stomach cases with the fluoroscope. In nearly all cases the injury was on the hands, and 39 of these doctors had cancer as a result.

Since bones and metallic objects are plainly visible on the fluorescent screen, it is quite natural that physicians should like to set broken bones and remove bullets, needles, and similar foreign bodies under the fluoroscope. But unless the roentgenologist knows his machine and has courage, both doctor and patient are in danger. The surgeon is always sure that one minute more and he will be through and sometimes he gets angry when the X-ray man says, "No more this time. You're at the safety limit now."

Whenever this subject comes up I remember a young man I saw once who was a living memorial to the menace of the fluoroscope in ignorant hands. He was a promising surgeon, had saved his money and taken graduate training, and was at last in line for an appointment on the staff of a well-known hospital. Then, during a vacation in an out-of-the-way region, he undertook to remove a needle from a woman's forearm. The only X-ray machine in the town belonged to a dentist and it did not occur to the young surgeon to doubt his statement that he knew how to run it.

With difficulty the visiting doctor finally got the needle out but when I saw him he was in a great medical center nursing the fragment of his right hand, most of which had had to be amputated because of the severe X-ray injury. Besides the suffering and loss of time and money, he faced the task of teaching his left hand to do what his right hand had previously done and making two fingers replace two fingers and a thumb.

With this specter before me I find the courage to protect both my technicians and myself from the unreasonable demands of the few doctors who understand neither the uses nor the dangers of radiation but attempt to dictate how it shall be used. There are fewer of these men every year, for the medical graduates of today know far more about X rays and radium than my generation of fledgling physicians.

CHAPTER XV

Something about Sunshine and Ultraviolet

What Is Ultraviolet?

If you will look at the chart of electromagnetic energy (see the frontispiece), you will find a narrow zone marked "visible light" and just beyond it a wider zone marked "ultraviolet." Ultraviolet, like X rays, is one small section of the great sweep of electromagnetic radiation which, as we know it today, stretches from the alternating currents of electricity to the gamma rays of radium and the cosmic rays.

This whole gamut of energy is basically one, and the various divisions or octaves are distinguished from each other by the qualities due to their varying wave lengths. Thus, the human eye can distinguish only that narrow zone of wave lengths between 3900 and 7600 Å. U.[1] (Ångstrom units) and hence both ultraviolet rays and X rays are invisible.

Sunlight and the Atmosphere

Obviously, on its way from the sun to the earth's surface, light has a long way to travel. On its way it passes through the shell of atmosphere which surrounds the earth.

In the greatly rarefied zone of the altostratosphere, the ultraviolet rays contained in sunlight fall upon the atoms of

[1] The Ångstrom unit, commonly abbreviated as Å.U., is one ten-millionth of a millimeter (0.000,000,1 mm.). It is simpler to think of 3900 A.U. or 7600 A.U. than of 0.000,04 cm. or 0.000,08 cm.

the gases present and knock out of them many electrons. This action electrifies the stratum known as the Kennelly-Heaviside layer which reflects radio waves back down to the surface of the earth and makes broadcasting possible. Strike one for ultraviolet, in behalf of radio.

Further down, the short ultraviolet rays act upon the oxygen in the air to produce a bank of ozone several miles thick, which, in turn, filters out of the sunlight some of the most irritating ultraviolet.

After this the light from the sun enters the lower portion of the atmosphere—a layer so full of fog and clouds and smoke, all of which impede the passage of ultra violet, that by the time sunshine reaches sea level not more than one per cent of it falls in the zone beyond visible light.

Variations in the Ultraviolet of Sunshine

From December until May, daylight in the northern hemisphere contains very little important ultraviolet, because it has been filtered through the clouds and fog and rain in our atmosphere. High humidity at any season cuts down the proportion of these rays in sunlight.

The time of day also affects the amount of ultraviolet: at noon the sun shines down from the zenith through a shallower depth of air than late in the afternoon when the sun is low in the sky and its rays must shine obliquely through the atmosphere.

Besides this, we reduce the percentage of ultraviolet in daylight by pouring into the air over our cities enormous quantities of smoke. London's smoke and soot are reported to cut down her solar ultraviolet by two thirds.

Nor is this all. In some parts of the United States the smoke pall of forest fires makes the ultraviolet content of sunlight almost as low in July as in January.

Thus it is clear that dry climate, high altitude, and lack of smoke increase the amount of ultraviolet in sunshine, while fog and rain, clouds and smoke reduce it sharply.

Ultraviolet and Plants

The leaves of plants are green because they contain chlorophyll—a substance very much like the pigment, hemoglobin, which makes blood red. Chlorophyll is what chemists call a catalyst; that is, its job is to start things going in which it later takes little active part.

The roots of a tree soak up water from the ground; the leaves absorb carbon dioxide from the air; the chlorophyll in the foliage captures light rays and ultraviolet from the sunshine. When all this has been done, the tree itself filches from the water and the carbon dioxide the hydrogen, oxygen, and carbon it needs and reassembles them into simple sugars out of which it builds both its skeletal framework and its starchy food. Sunlight therefore, is all-important to the growing plant.

Plants forced to live in the dark are pale in color and watery in consistency, they have a poor framework and will not bear a normal crop of fruit or seed. On the other hand plants kept continuously in bright light containing a large proportion of ultraviolet grow rapidly to an unusual height but also become prematurely old.

Ultraviolet and Animals

Experiment has proved that ultraviolet has a profound influence on animals as well as plants. For more than two decades research laboratories and experiment stations have harbored hordes of puny chickens, undersized rats, poorly nourished guinea pigs, and bewildered cows—all of them teaching us something about the functions of ultraviolet rays.

An animal exposed to ultraviolet absorbs calcium and phosphorous from its food readily and builds strong healthy bones, and its skin apparently has increased resistance to infections. Cows treated with ultraviolet give milk more potent to prevent rickets than the milk of cows not so irradiated, and hens that have ultraviolet regularly lay eggs which have shells thicker than usual, are ten times as anti-rachitic as ordinary eggs and also hatch more chicks.

What We Knew about Ultraviolet Before 1900

Centuries before our era the Egyptians worshiped the sun god Aton; over three thousand years ago the Pharoah Ikhnaton built sun baths for the treatment of the sick. Among the hills of ancient Greece were temples to Aesculapius where patients were bathed in fresh air and sunlight. Aristotle knew that without sunshine the leaves of plants would not be green; both Hippocrates and Galen—great physicians of the Old World—recommended sun baths; long before the arrival of Columbus in the Western Hemisphere the Incas used sunlight in the treatment of disease.

But with the decline of Rome and the rise of Christianity Western man turned his concern from this world and the things of the body and centered his thoughts upon the "mortification of the flesh" and life everlasting. Both the worship of the sun god and the medical use of sunlight were abandoned. During the Middle Ages only the Arabs continued to employ heliotherapy.

Not until the seventeenth century was there any real revival of interest in light among Europeans. Then Isaac Newton, passing white light through a prism, broke it up into the spectral colors at which cave men had stared in the rainbow. And presently it was found that light moves with enormous but nevertheless measurable velocity (approximately 186,000 miles per second). But not until 1801 did a German scientist (Ritter), by exposing silver chloride to spectral light, prove that in the dark zone beyond visible violet there are certain unseen rays which quickly blacken silver salts. These are the ultraviolet rays.

During the Napoleonic wars French military surgeons began to expose wounds to open air and sunlight. By 1815 the physician Loebel was using sun baths for a variety of diseases and by 1835 a handful of doctors were urging sunlight for the treatment of rickets and scrofula (tuberculosis of the glands of the neck). But the spectacular advance of surgery following the discovery of anesthesia at the turn of the century and the development of antisepsis following Pasteur's proof of the germ production of infection diverted attention from so commonplace a thing as sunshine. However, in 1877 two Englishmen—Downs and Blunt—reported that direct exposure to sunlight would kill many kinds of germs but that the fatal rays could be screened out and the bacteria protected by merely putting a piece of ordinary window glass in the path of the light rays. Another fifteen years and it had been discovered that ultraviolet had much more germicidal power than visible light.

Meantime, in 1890, Dr. Theodore Adrian Palm, an English physician who had traveled widely, published an article pointing out that rickets was prevalent wherever there was a lack of sunshine. This observation, now recognized as a medical classic, attracted no more attention at the time than the work of an obscure physician named Finsen was then beginning in Copenhagen on the treatment of tuberculosis of the skin with the carbon arc lamp.

By the close of the nineteenth century observation and experiment had established a handful of facts about light.

1. Besides the visible spectral colors there is in sunlight an invisible ultraviolet ray which causes sunburn and inflammation of the skin.

2. This ultraviolet light will kill germs if it strikes them directly but cannot penetrate ordinary window glass or more than a few millimeters of flesh and blood.

3. Exposure to sunlight or ultraviolet rays will cure many cases of lupus (tuberculosis of the skin) and the absence of these rays is associated with the disease of bones known as rickets.

4. The carbon arc lamp emits ultraviolet rays as well as light and heat and can be used instead of sunshine in cloudy weather.

CHAPTER XVI

Ultraviolet in Medicine

Ultraviolet and Tuberculosis

At a meeting of the Swiss Medical Association in 1904 Dr. Bernhard, surgeon to the Samaden Hospital, reported excellent results from exposing wounds and tuberculous infections of the skin to sunlight. Hearing of this, a young French physician named Rollier decided to test some of his own ideas about sunshine.

Rollier was particularly interested in tuberculosis of bones and joints. For four years he had worked in Kocher's clinic at Berne where many of these cases were operated on over and over, only to die or finally be crippled by their disease. Now he rented a house in Leysin and turned it into a "sun clinic."

Rollier did not put his patients into thick heavy plaster casts for months or years and neither did he operate on them. Instead he put them in bed on unsagging springs and firm mattresses, in positions which made diseased joints comfortable. The spine cases spent half their time on their backs with small solid pads under the deformed vertebrae and half on their stomachs with their chests propped up by wedge-shaped cushions which held their shoulders several inches above the bed and left their hands and arms free to move. The patients with tuberculosis of the hip or knee had firm cushions wedged beneath the pelvis and weights suspended from the lower leg in order to pull the infected joint surfaces apart. These positions not only relieved pain by immobilizing the diseased joints but also helped to correct deformities.

For some days after starting treatment a patient was kept lying quietly in bed in a room open to air and light while he got used to his new regime. Then his bed was wheeled out on a porch where for a few days longer he had air baths. Finally he had his first sun bath.

To begin with, only his feet were exposed; usually five minutes three times a day at the start, while his head and body were shaded. Gradually the line of exposure was moved upward—to the knees, to the thighs, to the abdomen. After about three weeks most of his body was being irradiated, but his head was always shielded from direct sunshine and his chest was usually not exposed. Treatment ordinarily was given in the forenoon; it always stopped at least thirty minutes before mealtime and never began less than an hour after eating. The midday heat was scrupulously avoided.

In spite of all these precautions, it was never possible to predict an individual patient's reaction. Many persons could eventually take three hours in the sun each day; some even more; but others could never approach that amount of radiation. Therefore each patient had to be watched carefully and nothing left to chance. Degrees of fever were recorded, pulse rates charted, weight checked, pain and other symptoms watched. At intervals X-ray plates were made to detect any visible evidence of improvement in the bones.

Following this system of his own Rollier found that, in the average case, pain and fever slowly declined, swollen joints gradually shrank toward normal size, pus dripped less and less freely from the open sinuses. Bit by bit the patient's skin turned brown, his appetite improved, his flabby muscles grew firmer. His voice lost the whine of the chronic invalid, his weight crept upward.

Once active infection had subsided and X-ray plates showed the formation of strong new bone, Rollier let his patients out of bed. Slowly they would begin to exercise, to walk again. And one day they would be discharged—bronzed, firm-fleshed, free from pain and fever, and obviously on their way back to full health and strength.

When the International Medical Congress met in London in 1913, for the last time before the First World War, Rollier reported that during the previous decade he had treated over a thousand persons and apparently cured some 83 percent of them. But in spite of these results he gained few recruits in those early years. It took a long time to convince most doctors that heliotherapy could do more for tuberculosis of the bones and joints than surgery. But in 1913 Dr. Pryor of Buffalo, New York, went to Europe to study sun treatment and in November of that year he began using it in the new J. N. Adams Memorial Hospital at Perrysburg, New York. From here the sun cure spread to other tuberculosis hospitals. In the United States it was the men working in these sanatoria who established heliotherapy on a sound footing.

Ultraviolet and Rickets

The next disease for which ultraviolet was used extensively was rickets. Although Dr. Palm had pointed out the correlation between rickets and lack of sunshine as early as 1890, it was not until twenty years later that much attention was paid to his contention. Perhaps this was partly because rickets had been known for so long. During the seventeenth century it was accurately described; for nearly three hundred years it had been observed in infants, small children, and young animals in captivity. Rickets keeps the body from absorbing and using calcium and phosphorus properly and therefore leads to soft bones, bowlegs, pigeon breasts, pot bellies, and square heads flat in the back. Furthermore children with rickets are susceptible to pneumonia.

The 1915 edition of Osler's *Principles and Practice of Medicine,* which I used in medical school, told us that from 50 per cent to 60 per cent of the children attending clinics in Vienna and London had rickets, and about the same time Dr. Hess of New York announced that over 75 per cent of the children less than two years old in that city showed signs of the disease. During World War I and the years immediately thereafter, semistarvation caused by the Allied blockade of Europe resulted in the appearance of a very severe type of rickets in the central part of the continent.

For years physicians had known that cod liver oil would cure this disease but it was apparent to everyone that prevention would be better than cure because it would avoid the bony deformities which persist after active disease has disappeared. It was also observed that rats fed entirely on white flour developed rickets and that babies fed condensed milk or patented infant foods containing excessive starch or sugar usually got rickets at the same time that they grew very fat. To raise lion cubs in a zoo had been impossible until a whole litter, already ill with rickets, was restored to health by a diet of milk, cod liver oil, and pounded-up bones.

In 1918 Drs. Hess and Unger distributed cod liver oil in one of the poor negro districts in New York City and proved that it would prevent rickets even in these underfed [illegible] babies. The next year Dr. Huldschinsky in Vienna treated with ultraviolet rays four children who had the severe post-war rickets then prevalent on the Continent. Within eight weeks these youngsters were practically well.

Dr. Hess too had been experimenting with ultraviolet and in 1921 he announced that the ultraviolet rays in sunlight or from a lamp would prevent rickets even when young animals were deliberately given a diet known to produce the disease under ordinary circumstances.

Fundamental Effects of Ultraviolet

Exposure to sunshine causes an immediate reddening of the skin which is due to the increased blood supply produced by the heating effect of the visible light and infra-red rays. Some three or four hours later another reddening appears which is due to ultraviolet. This lasts about forty-eight hours and is usually followed by tanning.

The skin when well tanned acts as a dark absorbing surface: it protects against excessive ultraviolet exposure by absorbing these rays, converting them into heat and shedding them into the adjacent air. However, even then sufficient ultraviolet reaches the blood vessels in the deeper layers of the skin to affect the animal body in many ways.

Penetrating into the skin these rays find there a substance called cholesterol which they turn into a powerful anti-rachitic; this material is then carried throughout the body in the blood stream. In other words, the skin, when stimulated by ultraviolet, produces and the blood distributes a chemical (called viosterol when manufactured in the laboratory) that will prevent and/or cure rickets. Furthermore, ultraviolet aids in the absorption of calcium and phosphorus from the food by the intestine, it promotes growth in infants and young children, and it prevents a drain of calcium from the bodies of pregnant or nursing women.

Medical Uses of Ultraviolet

Skin disorders

The local effects of ultraviolet make it useful in several skin diseases. It produces inflammation and increases the blood supply in the surface vessels. It therefore is of value in treating ulcers and wounds which are slow to heal. It often gives improvements in psoriasis and acne (two diseases of the skin which are essentially chronic and therefore recur over and over, requiring intermittent treatment over long periods) and, properly used, it will cure most cases of erysipelas promptly. Whether ultraviolet or X rays or the sulfa drugs is to be preferred in the latter infection must be determined by the attending physician.

Tuberculosis

General irradiation of most of the surface of the body is extremely valuable in tuberculosis of the skin, glands, bones, and joints. Certain other tuberculous conditions (e.g. tuberculosis of the bowel, throat, and kidney) are also sometimes benefited by ultraviolet irradiation, but ordinary tuberculosis of the lungs should not be treated in this way.

Sun baths can be used to advantage in high dry climates where sunlight retains considerable of its ultraviolet but in most of our cities lamps (carbon arcs or mercury vapor) must be used. I cannot make the point too strong that no one except an experienced doctor should undertake the ultraviolet treatment of tuberculosis. Much harm can be done by over-irradiation, no good will result from too little. Above all things, the patient himself must never take the responsibility for such treatment.

Rickets

Rickets can be cured by general ultraviolet irradiation of the body or by sun baths. The mechanism here is the production in the skin of the antirachitic known as activated ergosterol or viosterol and the transport of this substance throughout the body by the blood stream.

This does not mean that ultraviolet is a substitute for adequate vitamin D in the diet. Every child needs the proper amount of this vitamin in his food; if he gets it he will not develop rickets. Taken every day, 1½ to 2 pints of whole milk containing 200 units of vitamin D per pint will prevent rickets in children between infancy and adolescence. Milk of this strength can be obtained by adding 1⅓ teaspoonfuls of standard United States Pharmacopeia cod liver to the quart or by the exposure of the milk itself to ultraviolet.

Other foods can be made antirachitic in the same way—e.g. meat, cream, cereals, eggs, lettuce, spinach, etc. But the wholesale irradiation of food would probably be unwise, for this reason: experimental animals fed entirely on such foods are prone to develop diseases of the heart, blood vessels and kidneys, the precise cause of which is still uncertain. Until we understand this more clearly, it would be foolish to go in too heavily for irradiated foods.

Pregnant women and nursing mothers must supply the calcium needs of the growing child and because of this are in danger of having the calcium drained from their own bodies and bones. They should therefore have abundant calcium and phosphorus in their diet and in addition at least 800 units of vitamin D each day to help them absorb and utilize these vital minerals. The extra vitamin D can be secured through ultraviolet radiation, through the use of irradiated milk or cod liver oil. (Standard cod liver oil contains 310 units to the teaspoonful.)

Other uses

A good many physicians, on the basis of clinical experience, feel that ultraviolet is an aid during convalescence from severe debilitating infections and in the delayed healing of fractures. Perhaps from dietary deficiencies, some people seem to have lost the ability to build sound new bone; if this is really the case, ultraviolet should help them to absorb all possible calcium from their food and to use it to the best advantage in repairing the broken bones.

Sterilization of the air

Recently a good deal of attention has been given to airborne infections. It appears that most colds and many other respiratory infections are spread by means of tiny droplets sprayed, spoken, sneezed, and coughed into the air in enclosed spaces. "Moist" consonants, such as *f*, *p*, and *s*, project these minute droplets by the hundreds. Since it is impossible to mask effectively every person with a respiratory infection, studies have been made of the practicability of sterilizing the air with ultraviolet.

It is a fact that many people carry in their noses and mouths, while they are perfectly well, germs capable of producing virulent infection in others; this makes it likely that visitors and employees introduce into hospitals many infections which the patients did not bring in when they were admitted. Hence the importance of the investigations into the matter of sterilizing air.

It has been found that germs in the air of hospital wards increase as the number of patients rises, as more people move about in the ward, and whenever the circulation of the air becomes brisker than usual. When ultraviolet lamps are installed in the bed cubicles in hospital wards, in operating rooms, or in schoolrooms, the number of germs in the air as shown by bacteria count falls off, ordinarily more than 50 per cent. The incidence of respiratory infections has also been sharply reduced by this method of irradiating the air, and the number of postoperative infections in surgical patients cut down. Epidemics of measles, mumps, and chicken pox are reported to have been checked by simply exposing the air of schoolrooms to the rays from ultraviolet lamps.

This study is still going on; within the next few years it may give us important results. Since the common cold accounts for the lion's share of all absences from school and from work, its prevention alone if practicable would have an enormous economic value.

Testing the circulation

Quite recently a spectacular use for ultraviolet has been developed, for which young Malvern has shown great enthusiasm since an incident in the hospital a few months ago.

He had in his ward a patient with gangrene of the foot and lower leg. A difference of opinion grew up between various members of the surgical staff concerning the necessity for amputation. The man objected; he was a mechanic and he felt that he would have to abandon his trade if his foot were removed. Malvern's ready sympathies were aroused by the plight in which his patient found himself and he came down to discuss with McDonald and me what might be done.

The result was that next morning he appeared with his mechanic friend in the X-ray department where Miss Randolph had ready for him in a darkened room an intravenous set and an ultraviolet lamp. He injected a harmless material called fluorescein into the man's arm vein, and then we turned off all lights, switched on the ultraviolet lamp, and trained its radiation on the patient's foot and leg.

It takes less than half a minute for the blood to make the circuit of the body and we knew that, if the blood vessels in our man's extremities were still open, the fluorescein would be down there in a few seconds and would cause the leg to glow with a brilliant gold-green luster. Almost breathlessly we waited. Physicians do not enjoy discovering evil things about their patients and I knew that Malvern was hoping desperately against hope for something good.

"Ye gods!" he exclaimed suddenly, "How time drags when you don't want it to!"

I smiled in the darkness, remembering my own days as a young doctor who often found it hard to accept the inevitable philosophically.

And just then the patient's leg lit up with a rather ghastly greenish light, telling us that some at least of the blood vessels were still open to the circulation. Jubilantly Malvern wheeled his patient off and later in the day he sent me word that amputation had definitely been abandoned. A few weeks afterward the man walked out of the hospital on his own power, leaving a beaming interne behind.

Dangers of Ultraviolet

Although very few laymen would venture to treat themselves with X rays or radium many people feel quite competent to prescribe sun baths or ultraviolet treatments. But there are real dangers in the use of ultraviolet.

In the first place, severe burns result from overexposure, and he who considers a bad sunburn of no importance will change his mind once he has had one.

Then there are certain conditions in which ultraviolet is positively forbidden: for example, heart disease, arteriosclerosis, high blood pressure, acute infections with high fever, impaired kidney function, diabetes, progressive tuberculosis of the lungs, and the type of goiter known as toxic or exophthalmic.

Heavy irradiation over the abdomen has been followed in experimental animals by ulcers in the stomach and/or intestine. Strong sunlight and/or ultraviolet rays damage the unprotected eye ("Kleig eyes" and snow blindness). For this reason patients wear colored glasses while taking ultraviolet treatment.

Some apparently healthy persons have headache or nausea after taking sun baths or ultraviolet treatment and others become nervous and are unable to sleep. In fact overexposure may produce such symptoms in anyone.

People whose faces are weatherbeaten from long exposure to sun and wind develop cancer of the skin of the face and neck more often than other people of the same age. Blondes and persons with red hair cannot take as much sunshine as brunettes; they do not tan enough to protect themselves against excess radiation.

All these considerations point to the conclusion that sun-bathing and ultraviolet treatment are medical procedures which should be used only under the direction of a physician. Intelligent supervision is more essential than enthusiasm for a coffee-brown skin and more harm than good results from inexpert use of this radiation. Ultraviolet is no cure-all, although no doubt another fifty years of observation and experiment will teach a new generation of doctors much that none of us now suspect.

Clothes and Ultraviolet

Many fabrics will not let ultraviolet through. Cotton, silk, and wool pass very little of the important wave lengths and baby flannel cuts off all the antirachitic ultraviolet. Rayon transmits considerably more and feathers curiously enough, permit passage of most of the ultraviolet. Therefore chickens can absorb these rays without molting.

The spaces between threads and the weight and porosity of the fibers themselves are very important factors in the transmission of ultraviolet; thus, tightly woven cotton is almost as impervious as wool, while in openmeshed fabrics, the threads absorb only about 10 per cent of the radiation.

All this suggests that there is more than moonshine in the notion that the modern woman's scanty garb is more healthful than her boy friend's modest woolens.

Transmitting Windows

People who cannot lounge in the sun or bask under ultraviolet lamps sometimes ask whether they ought to install special transmitting windows in their homes, offices, and schools. The answer is usually No.

Some of the glass for sale in the market transmits a good deal of ultraviolet and some very little. Most of it sacrifices weather resistance for ultraviolet transparency, thus increasing the over-all expense. Furthermore, all varieties deteriorate with age and use.

But, however excellent the glass, a person in ordinary clothes several feet from a transmitting window would have to sit there fifteen or twenty hours a day to get the same amount of ultraviolet he could get in a five-minute walk outdoors at midday. South exposure means much more sunlight than north exposure, it is true, but everyone cannot sit beside a south window. In climates where winter sunlight contains little ultraviolet to start with, one would certainly pay an enormous price for a minute quantity of these rays.

Even in a nursery equipped with transmitting windows of high quality, a baby would have to spend most of his time both naked and close to the windows if he was to get any benefit. It would seem simpler and more effective as well as much cheaper to go outdoors for a five-minute walk at noon and take the baby, if any, along. Indeed, at the present time, the advisability of using transmitting windows to acquire a suntan while shaving, bathing, or loafing seems very questionable.

Ultraviolet Lamps

Since rain and smoke, fog and clouds filter out of sunshine so much of its natural ultraviolet, it is often necessary to resort to lamps in order to get ultraviolet rays when and as we need them. There are today three types of such lamps in common use: mercury vapor quartz, carbon arcs, and tungsten filament lamps.

The first type consists of a quartz tube containing a small amount of liquid mercury; an electric current heats and vaporizes the mercury which then emits a strong beam of radiation. The quartz wall of the tube holds back only the very short, irritating ultraviolet rays (below 1850 Å.U.). The advantage of the mercury lamp is that it gives off a large amount of ultraviolet (nearly one-third of its output is in this zone, as compared with one per cent of sunlight at sea level); its disadvantage is that its radiation is spotty—here a group of rays and there none, all the way from the very short ultraviolet to the infrared—whereas that of sunshine is continuous. One might compare a natural sun bath to a douche from a large hose and treatment with a mercury vapor lamp to a fine spray striking the skin only in scattered spots.

The carbon arc has two pieces of carbon set a short distance apart; between them an electric current is passed. The current gradually bores a hole into the end of the stick of carbon and from these craters a flood of ultraviolet rays is poured out as well as much heat and visible light. The ultraviolet of the carbon arc is like that of sunlight to the extent that it consists chiefly of the longer wave lengths (beyond 2900 Å.U.), but for all that, the output of this lamp is by no means a duplicate of sunshine.

There are also lamps with a tungsten filament, housed in bulbs of transmitting glass, which give off useful ultraviolet in small amounts.

Each sort of lamp has advantages and disadvantages. Mercury vapor lamps are simple to operate on ordinary alternating current, they are clean and quiet and emit no sparks. But the quartz tube is easily broken and expensive to replace, and it deteriorates with use. More important, the radiation emitted is poor in the long ultraviolet rays so useful to man and plentiful in sunlight.

Carbon arcs, on the other hand, give off much ultraviolet similar to that of sunlight. But the arcs are expensive to operate (requiring a rotary converter to turn ordinary commercial alternating current into direct current), they are difficult to keep in adjustment, they are noisy, they smoke, they often sputter out bits of hot carbon on the patients. Besides this, the treatment takes longer than with mercury vapor lamps.

Finally, the tungsten filament lamps have the bulk of their output in the infrared and only a small percentage in the vital zone of ultraviolet (between 2900 and 3200 Å.U.). This means very long exposures frequently repeated, thus offsetting to a great extent the convenience of using a bulb which can be screwed into an ordinary lamp socket.

By and large, carbon arcs are chiefly used by physicians in treating diseases (such as tuberculosis of lymph glands or bones) in which radiation of the entire body is indicated, while mercury vapor lamps are used more often in treating localized diseases of the skin. Either of these lamps can be used successfully to treat rickets. The tungsten filament lamps can be used in nurseries to prevent the development of rickets, but to cure this disease would require daily exposure several hours long, over a period of weeks.

The usefulness of any of these lamps in the family bathroom, so far as the general health is concerned, is highly dubious and all of them present certain electrical hazards which make it wise to keep them out of the home except when a physician prescribes their use for a specific purpose. There is no scientific basis for thinking that their regular use by persons in good health will increase resistance to colds during the winter months.

CHAPTER XVII

Technical Uses of X Rays and Ultraviolet

IN 1912 research scientists began using X rays to study the structure of crystals and molecules. Since then this investigation has expanded to include the architectural pattern of atoms, the arrangement of the fibers in cellulose, and the grain size in many commercial materials. In this way much knowledge of practical value has been gained.

For instance, manufacturing processes often change grain size and therefore alter behavior, as in the heating of metals. An X-ray study of duralumin in airplane propellers is reported to have shown distortion due to vibrational stress and to have resulted in improved propeller design as well as choice of better alloys. X rays also reveal structural changes in metals caused by rolling and by the addition of alloys; the X-ray examination of lubricating oils disclosed the structure, shape, and size of the molecules as well as the way they are bound together.

The metal trades have indeed a good many uses for X rays. Roentgenograms will show "strain" in metal objects well before a danger point is reached; they check the fit of screw threads; they disclose concealed breaks in insulated wires and cables or in coated metals; they show slag inclosures, cracks, and blowholes; they show defects and faulty rifling in gun barrels, asymmetry and defects in ball bearings, cracks and metallic particles in porcelain insulators. They will find thinned spots in the walls of cylinders for oxygen and liquid air and determine whether the grid and filament of radio tubes are in their proper positions and the parts of intricate assembled machines properly placed.

X-ray examination is the only way of testing a welded joint without damaging it. During the construction of Boulder Dam three X-ray units were used to check all such joints; a total of seventy-five miles of welding was examined in this way. Alcoa X-rays all its aluminum and light-alloy castings. The United States Army has X-rayed all its castings since 1932. The United States Navy X-rays all its steam boilers.

X rays are in wide use in defense industries. Million-volt machines photograph steel castings five and six inches thick in two or three minutes. If such castings show flaws they are promptly returned to the foundry where the defects are chipped out and new metal is welded in; then they are sent back for re-ray before being used. X-ray tubes are placed in the center of boilers and with a single exposure a whole series of films is made around the entire circumference. Every welded joint in our instruments of war is checked with X rays.

Cartridges are X-rayed to detect improper filling; pipes and wiring in walls of buildings are located by X-rays; reclaimed rubber is examined for nails and other metallic foreign bodies, and tires for internal breaks and tacks.

In peacetime X rays also have their industrial uses. They are used to study the arrangement of cellulose fibers in fabrics and wood, because it is the structure of cellulose which largely determines elasticity, tensile strength, shrinkage, and dyeing properties. For similar reasons X rays are employed in the explosive industry. Wood is examined for concealed cracks, knots, wormholes, spikes, and areas of decay. Before the present war, for instance, the old wood in the cathedral at York in England was X-rayed for signs of rotting.

By measuring the absorption of X rays one can determine the precise thickness of sheets of leather, glass, metal foil, paper, and films of paint and learn whether the thickness is uniform or not. The composition of certain materials can be tested in a similar fashion—e.g., silk weighted with metal, rubber containing filler, glass mixed with metals, flour adulterated with sand or sugar with chalk.

X Rays and Ultraviolet as Detectives

Customs authorities X-ray sealed packages for bombs and trunks for false bottoms and contraband metallic objects, and the police have a multitude of uses for ultraviolet rays.

The oils left in indistinct fingerprints will fluoresce under ultraviolet, and, when zinc sulphide is dusted over the surface, the fluorescence will often increase enough to give good sharp photographs of the prints. Detectives also use these rays in studying stains. In the presence of concentrated sulphuric acid blood fluoresces a yellowish red under ultraviolet; alkalinizing the solution causes the fluroscence to become a brilliant carmine. Very small amounts of blood will show these characteristics and bloodstains on washed clothes can often be photographed with ultraviolet light. Furthermore, ultraviolet will frequently differentiate between various types of stains on clothing. For example, urine stains fluoresce a yellow-white while semen fluoresces blue-white.

Different sorts of ink can be detected with ultraviolet. Thus, if a will or legal document is altered, the original ink and that used in the alterations will fluoresce in two different ways under ultraviolet light. The inks used on bank notes are said to have a characteristic fluorescence; currency can be marked with an ink which is invisible with ordinary light but which will fluoresce under ultraviolet rays.

Erasures, both mechanical and chemical, almost always leave behind either a bit of ink or some marks on the paper which can be seen with ultraviolet. Changes in the surface texture give plainly visible spots where the fluorescence is affected. Aniline inks, even although so faded as to be invisible to the eye, leave behind on the paper a residue which will fluoresce under ultraviolet. Laundry marks after having been supposedly eradicated can usually be seen under ultraviolet, and most substances used in invisible writing will glow under these rays—e.g., fruit juice, milk, vinegar, saliva, urine, etc. Signatures which cannot be seen at all can often be photographed with ultraviolet.

With a mercury vapor lamp it is frequently possible to detect forgeries. First, the visible light and infrared must be filtered out of the beam of radiation by a screen of nickel oxide. Then the document in question is placed inside a cabinet which can be darkened at will, and the beam of ultraviolet rays is directed upon it. The color with which the paper fluoresces will tell what type it is: pure linen rag glows with a bluish tint, pure cotton rag is clear white, chemical wood pulp a dark grayish-brown, and mechanical wood pulp almost black. If different types of ink have been used in the document itself or in the signature, the fact will be shown by the different colors in which the printing or writing fluoresces.

Finally, when paper is so charred by fire as to be uniformly black, any printing or writing on it can often be seen on photographs made not with ultraviolet but with infrared rays.

Very important, none of these examinations injures old documents in any way.

Scholars Have Use for X rays and Ultraviolet

There is sometimes good reason for doubting the authen ticity of ancient books and manuscripts. Writing howevei faded it may be is usually plainly visible under ultraviolet. Using these rays very old biblical scripts have been found to include both erasures and additions, and parchments from which monks once erased earlier inscriptions in order to re-use the surface have been discovered to show several sets of superimposed handwritten compositions.

Museums X-ray many of their paintings. Since the pigments used by the old masters are more opaque to X rays than modern paints, one can easily detect older originals beneath alterations and additions made by recent artists.

Museums also X-ray mummies. There are two reasons for this. First, jewelry and amulets can be located on the roentgenograms and the mummy thereafter unwrapped with little damage. Second, genuine mummies can be distinguished from fakes because in genuine specimens the bones will be arranged in some semblance to a human skeleton while in fakes they will be disjointed and jumbled together with no regard for anatomical arrangement.

Gems and X rays and Ultraviolet

Dealers in gems have some interesting uses for our mysterious rays. For instance genuine diamonds differ from imitations in several ways: genuine stones are transparent to X rays and fluoresce under ultraviolet, while paste diamonds are opaque to X rays and do not glow under ultraviolet. Cultured pearls do not fluoresce under ultraviolet unless they contain uranium, and on the roentgenogram they show layers arranged concentrically around the core of mother-of-pearl. Genuine natural pearls, on the other hand, do fluoresce with ultraviolet and on X-ray films show irregular patches of light and dark.

Natural blue sapphires do not fluoresce; natural white sapphires show an orange-yellow glow; synthetic blue sapphires are reddish-purple under ultraviolet. Synthetic rubies fluoresce a much deeper red than natural ones, and garnets do not fluoresce at all.

Unusual Uses of Ultraviolet and X rays by the Physician

Now and then it may be wise for a doctor to behave like a detective. For instance, he may need to know whether a patient has been taking aspirin or quinine recently. This information he can readily secure without tipping off the patient by examining the urine under ultraviolet light. If the person has been taking aspirin, his urine when alkalinized will fluoresce violet; if he has been taking quinine the color will be green.

A more characteristic new use for ultraviolet is in searching for the germs of tuberculosis in the sputum. The sputum is spread in a thin layer on a glass slide and stained with a dye called carbol-auramin. Then the slide is put in the microscope and a beam of ultraviolet focused upon it. Under low-power magnification any tuberculosis bacilli present will shine a bright yellow against a dark background. This type of examination, McDonald tells me, is very dependable and saves much time and effort in many cases.

There are some curious differences in the fluorescence of various body tissues. For instance, the skin of whites fluoresces under ultraviolet while the skin of the colored races does not. Normal healthy teeth fluoresce white, and defective teeth often show a reddish cast. Naturally blonde hair fluoresces, while artificial blondes do not. Hair infested with ringworm shines bright green under ultraviolet; this may conceivably come to be useful to schoolroom inspectors.

Foods are examined with both X rays and ultraviolet. Packaged food stuffs are carried along on a conveyor in front of a fluoroscopic screen on which the operator can spot at a glance spoiled foods and metal objects accidentally left in candy bars, plugs of tobacco, cartons of cheese and chocolate. Pithy oranges are picked up in the same way.

Under ultraviolet fresh eggs fluoresce a pale red; as they age this becomes bluish and gradually fades. Butter glows yellow and margarine blue; as little as 15 per cent adulteration with margarine can be detected. Fungi in cheese fluoresce a brilliant pale green, and natural ripening can be distinguished from false. Healthy potatoes do not fluoresce, those affected with ring rot are a pale green under ultraviolet.

Recently a rather amusing new use for X rays has been worked out. It consists of an invisible but permanent tattooing.

Most tattoo marks can be removed by injecting a chemical which causes the skin to slough and carry away with it the marks. But in this new method the tattooing is done with substances which, in extremely small quantities, glow with brilliant colors under a beam of X rays. Only by cutting away the entire area of skin could one remove these marks.

The inventors think that their system would be a useful way to identify individuals and brand habitual criminals. But I suggested to Dr. Douglas that the surgeon, after closing his incision, should leave behind, indelibly inserted into the skin, the date and a brief description of what he has done. It would be hard for a patient to alter his past history to suit himself when confronted under the fluoroscopic screen with some such inscription on his own skin as this: "10-14-'42. Gall bladder removed, with stones, W.S.D., M.D."; or "10-14-'42. Uterus removed. Ovaries and tubes normal, left intact. W.S.D., M.D."

CHAPTER XVIII

Odds and Ends There Was No Other Place For

Two questions I have been asked so often that I am sure many people are interested in them.

One is about radioactive water. A few years ago some quack outfit advertised jars which were said to render water kept in them radioactive and assured the public that such water would cure a host of diseases. This swindle apparently proved unprofitable; at any rate it has dropped out of sight. But pseudomedical fakes have a way of bobbing up at intervals, exploited by shrewd promoters. Witness the notorious Abrams' apparatus so widely used in the early Twenties and still featured here and there by various healing cults and the Koch cancer cure which did not get its knockout blow until 1942.

Now, of course, no earthenware jug can make water radioactive, but unfortunately really activated water was sold to the public for some time and a number of people who used it died of radium poisoning. Anything as dangerous as radioactive substances should be given a wide berth by everyone except those thoroughly trained in its use and fully aware of its hazards. Such things should have no place in the self-medication so dear to Americans; no reputable newspaper should permit them to be advertised in its columns and no decent drugstore should sell them to anyone.

The second question concerns the removal of hair with X rays. At present there are comparatively few advertisements in our papers declaring that superfluous hair can be destroyed painlessly and permanently by radiation, but this bit of quackery also may be revived at any time. The truth is that this is so dangerous an undertaking that no honest roentgenologist will attempt it. For the margin between a dose of X rays too small to do any good and one large enough to cause serious permanent damage to the skin is narrow and uncertain.

I remember an attractive young woman who came into the department in great distress a few years ago. She said she had been worried by hair on her legs showing through sheer stockings and had gone to a commercial X-ray laboratory which advertised the guaranteed removal of such blemishes. True enough the hair had been destroyed but now, two years later, she was more disfigured than ever.

The skin from her knees to her ankles was so red and mottled and streaked that she had to wear heavy stockings to conceal it. And recently she had noticed a sort of sore in one area. When I examined her I found not only that nothing could be done to restore the skin to normal but that she was developing a cancer at the site of the ulcerating sore. She illustrated the double-barreled danger of attempting to remove hair with X rays: greater disfigurement than ever and the appearance of cancer in the damaged skin.

Other odd complications and strange situations continually arise in the life of the radiologist. Some of these form the basis of the remainder of this chapter.

To Whom Do X-ray Films Belong?

Some people are annoyed if we do not give them the films we make during their examination. Their stock argument is that they have paid for their "pictures" and are rightfully entitled to the possession of them. The radiologist's counter-argument is that the patient pays not for the films themselves but for his services as a medical specialist and for the information afforded by the X-ray examination. This dispute has been so prolonged and so acrimonious that it has figured in a number of court decisions, most of which have bolstered the position of the radiologist. Is this then one of those dust-dry, contra-common sense opinions for which lawyers and judges are famous? Suppose we consider the matter for ourselves.

For years the medical profession looked upon the roentgenologist as a sort of super-photographer who was not entitled to the same standing as other specialists. At the beginning there was some excuse for this attitude, since many pioneers in X-ray work were physicists or engineers or research men or technicians rather than practicing physicians. Doctors knew little about vacuum tubes and transformers and high-voltage current and considered X-ray diagnosis of so little practical value that they were glad enough to leave it largely to technical men. When I was in medical school little use was made of X rays in the examination of patients and still less in treatment, and only one semester hour in this subject was included in the course of study. Not until World War I did X-ray work come to be regarded as a specialty really worth a man's while to master.

Even now many doctors think of roentgenology as glorified photography and of the roentgenologist as a sort of substandard technical man. Such physicians seldom give the X-ray laboratory a history of the patients they refer for examination. They usually have their secretaries call Miss Randolph and tell her that Mrs. So-and-So will be in tomorrow for gall bladder study.

Now when this is the attitude of doctors there is no reason for surprise when the public reacts similarly. They go to a photographer's studio, pay his price, and come away with a stack of prints; they come to our department, pay a fee, and expect to get an envelope full of films for their money.

But today's trend is in the opposite direction. Physicians are coming to look upon the roentgenologist as a medical consultant who is entitled to all available knowledge of the case before he examines the patient, and not as a mere photographer who makes pictures of various parts of the body on order. Not many doctors now stamp around warning the radiologist to mind his own business and stay within the narrow limits once set for him. This added prestige incites the X-ray man to make the most thorough study he can and to add as much as possible to the data which will serve as a guide in the patient's treatment. Give a man a bad name and he is tempted to live up to it; recognize the value of his work and he will try to increase its worth.

After all what the patient and his family are interested in is not shadows on sheets of transparent cellulose; they want to know what is wrong and what can be done about it. What they pay for is information—a diagnosis—not pieces of gelatin-coated film. That being the case, the roentgenologist considers himself a better custodian of the films he has made than the patient.

There is a good deal of evidence that he is right. In the first place most roentgenograms are meaningless to the untrained eye. That it could scarcely be otherwise any reasonable person will admit when he finds out that it takes a doctor of medicine two or three years of graduate study to learn the rudiments of X-ray interpretation and the rest of his life to master it. Physicians without this training and experience do not interpret X-ray films well and most nonmedical people might as well try to read Sanskrit.

I recall a self-assured young woman whose father came to us for examination. It turned out that he had a serious non-tuberculous lung infection and a functional stomach disorder but no actual organic disease of the digestive tract. When I finished my study I wrote a detailed report of my findings to the physician who referred the patient to us but the daughter brushed this aside and demanded that the films be delivered to her.

"We're not paying you for what you think," she said arrogantly, "or for what you've written down on that piece of paper. You've made a lot of pictures of my father and we want them. I want to see them for myself."

Having learned the futility of arguing with self-satisfied youth, I picked no quarrel with her.

"Very well," I said, "if that's the way you feel about it."

I handed her the bulky manila envelope without further comment. She fumbled inside it, pulling out film after film and looking at them with puzzled eyes.

"What's the matter with them?" she exclaimed. "I can't see anything on them."

"There's nothing wrong with them," I replied. "They're negatives, that's all. You have to hold them up to a strong light to study them."

I set one of the chest films in the viewbox in the proper position.

"Why don't you sit down here and look over all your father's films? I'm going out to lunch and you may use my desk if you like. One of the technicians will be here, of course, but you won't be in anyone's way. You're free to stay here all afternoon if you want to."

When I returned from lunch Miss Randalph met me with a smile.

"Your young lady didn't last long," she explained. "After she had looked at all the films twice over—most of them upside down—she got up and said she couldn't tell anything about them and she guessed she'd better take your report after all."

No better proof than this of the meaninglessness of X-ray films to the untrained observer need be offered unless, perhaps, I mention the common uses to which such films are put in the courtroom. Over and over I have seen lawyers or physicians who were devoid of knowledge of X-ray interpretation displaying films of the chest or spine or pelvis—usually wrong side up—to a jury who stared owlishly at them in blank ignorance of their meaning.

A second reason we like to keep the films ourselves is in order to preserve them. Ever since Miss Randolph gave an industrial accident patient the films of his injured spine for overnight display to his family, only to have them vanish permanently in less than twelve hours, she has insisted that the one way to make sure films will be lost is to give them to the patient. I do not go quite that far, because it seems to me that now and then a man has a legitimate reason for wanting his own roentgenograms, but I am sure that in all cases where legal action is even a remote possibility the wise roentgenologist hangs onto his films until a final settlement has been reached.

Another point is the difficulty of storing X-ray films in the home. The larger sizes are too big to go into bureau drawers or suitcases, and private houses are not equipped with steel filing cabinets. If the films are folded or rolled up, the surface is likely to crack. If fluid is dropped on them, they spot. If hot water is spilled on them, the emulsion melts and runs off taking the photographic image with it.

After such explanations most people admit that their X-ray films are of most use to them in the hands of those who understand them and have a place to keep them safely stored. In the case of outpatients our routine procedure is to send the films together with my interpretation of them to the physician who referred the case for examination; if he, in turn, wishes to turn them over to the patient, he is free to do so. In the case of persons in the hospital, my report is put on their charts and the attending doctors come downstairs to look at the films and discuss them with me, but the films themselves are filed in the department.

Of course we take circumstances into account. If, for instance, we have a series of chest films on a woman suffering from tuberculosis and she decides to go to another part of the country for treatment, we do one of two things: either hand over to her the films together with the readings made of them, or mail them to the doctor who is going to take care of her in her new location. Indeed our stenographer spends a good deal of her time copying reports which have been requested by physicians whom patients have subsequently consulted.

Should X-ray Reports Be Given to the Patient?

Now and then we see someone who does not ask for his films but does demand that the report of his examination be given to him instead of the physician who sent him in. On the face of it this seems reasonable enough, but closer consideration shows that this plan, if generally adopted, would result in harm to the very people who insist on it. I can best show what I mean by illustration.

A doctor once referred a man to me for X-ray study of the digestive system, in order to rule out possible infection of the bowel before embarking on the surgical treatment of a rapidly progressive pulmonary tuberculosis. The patient was suspicious and became angry when he learned that I intended to make my report to his physician rather than to him. He had much to say about the mythical "medical trust."

"You fellows are all in cahoots. I guess I know a little something about myself. My trouble is below the belt, but Doc Calhoun keeps harping about my lungs all the time. And you're standing in with him. But I got my rights and I want to know what you've found out before I begin paying him a lot of dough to do things to my chest."

Now, suppose I had given my report to that young man. He did not realize that tuberculosis of the lungs often causes digestive symptoms and often spreads to the intestine and, finding that I had discovered nothing wrong with his gastro-intestinal system, would probably have concluded that his doctor and I were merely combining to run up a bill on him and were not telling him the truth. The next step would have been to change physicians and put off treatment of his tuberculosis, and the third step would have been long, expensive invalidism.

The fact is that, in most cases, X-ray study is only part of a more comprehensive examination and that it is often undertaken in order to rule out certain possible complications. Therefore, if the roentgenologist were to give his report to the patient direct, he would supply only part of the true picture of that person's physical condition. Precisely because many people think of X rays as a sort of magic eye which can reveal everything that is wrong with them, the conscientious roentgenologist will not help them deceive themselves into thinking they know all, once they have read the X-ray findings. But we, none of us, object to furnishing an extra copy of our report which the doctor can give his patient along with a summary of the whole examination.

There are those who believe that roentgenologists deliberately make incorrect interpretations of their findings. Now anyone may make a mistake, and so long as they are human roentgenologists will sometimes be wrong. But they are certainly not so apt to be wrong as persons who have had no training whatever in X-ray work. As for deliberate misrepresentation, I admit the possibility. I make no claim that all doctors or all radiologists are equally competent and completely without sin. Perhaps there should be an angel with a flaming sword to keep the inexpert and the untrustworthy out of the medical profession and all its branches, but no such angel exists at present. Our medical schools do their best to select the best students from among their applicants and licensing agencies have power to rescind a doctor's right to practice if he is proved incapable or morally unfit. But so long as physicians must come from the general population, none of this guarantees the purity of individual medical men. Nevertheless, in twenty-five years' experience, I have personally known of no more than a half dozen cases of deliberate falsification of X-ray reports. Errors of interpretation and judgment there will always be, but I think it self-evident that these will be fewer if X-ray interpretation is left to trained personnel than if it is entrusted to patients and amateurs.

Collections of X-ray Films

Aside from the danger of damage and loss, there are other good reasons for keeping the original films or small copies of them on file in the laboratories where they were made.

For instance, when the roentgenograms are easily available, they can be studied by any physician called in consultation and also during future illnesses. This is sometimes very important. I remember young Malvern's excitement at seeing a bullet in the back of a boy's skull until I called his attention to a set of films made five years before which showed the same bullet in exactly the same spot.

It may become essential to be able to state positively that on such and such a date the patient had or did not have

X-ray evidence of duodenal ulcer or an enlarged heart, of tuberculosis of the lungs or gallstones. The chest films now being made of men examined under the selective service system form a case in point: when the war is over and the question arises whether a given man had pulmonary tuberculosis when he was inducted into the armed forces, there need be no uncertainty about the answer. A look at his dated chest film will settle the matter.

Then large collections of films have research value. In an institution where I worked for a time some years ago, there was such a collection on tuberculosis. It consisted of a series of films of each patient's chest during his illness plus films of his lungs after removal from the body at autopsy plus a complete report of the gross and microscopic examination of those organs in the pathological laboratory. The man who could not learn much from material of this kind must be a dolt indeed. And it is largely by painstaking study of such collections of films that roentgenologists increase their knowledge.

Nor is this the only important use of such files. It is by means of such collections that we train young doctors in X-ray interpretation. To set up one film after another and say to your students, "This is what pneumonia looks like" is poor teaching; but to have our internes bring down the clinical charts of pneumonia patients they have been following in the wards and then show them the films of those patients' lungs during the acute infection and after recovery or death, together with McDonald's slides of tissues he removed at postmortem, is good teaching. In this way we make sure that our yearly crop of new doctors understand the use of X rays better than we did when we entered practice. And in this same way, those who decide to become specialists in radiology learn the meaning of the varying shadows on roentgenograms.

Should Patients Ever Go Directly to the Radiologist?

So long as the roentgenologist was considered a mere photographer, it was the custom for him to accept only those patients referred to him by other doctors. And there was a good deal to be said for this plan.

Some people have the idea that X rays can tell them everything they need to know about themselves and therefore neglect other valuable methods of examination. I remember an elderly man who once came into my laboratory accompanied by his entire family, to ask me to X ray his "innards." When I tried to find out what his symptoms were and why he thought he should be X-rayed, I came up against a blank wall: he merely repeated over and over that he wanted me to make "X-ray pictures" of his "innards." Now to make a report of negative findings to such a patient directly would give him ground for believing that all was well with him when actually some other type of examination might disclose a serious ailment. Furthermore many people do not understand that disease in one organ often produces symptoms in many other parts of the body. Therefore we formerly turned away from our offices those persons who had not first consulted another physician who had made sure they needed X-ray study. And this cut down the volume of unnecessary work we had to do.

But to recognize the basis for this practice is not to approve it completely. Many conditions, if they are to be correctly diagnosed and treated, require the co-operation of two or more physicians, but it is not justifiable to insist that this co-operation always follow the same pattern. A competent roentgenologist is quite as well qualified to know which patients should be sent to another doctor for further examination as the general body of physicians is to select those persons who need X-ray study. Roentgenologists and radiologists are graduated in medicine and they take the same examinations as other doctors in order to be licensed to practice. It certainly should be no harder for the X-ray man who has examined a patient's stomach to persuade that patient to go to a good physician for treatment than for a doctor to induce patients to go to an X-ray laboratory for examination.

Only a few years ago the roentgenologist was not supposed to explain his findings to the patient. That was always left to the referring physician even though he might not understand the report very well himself. I recall vividly a clash I once had with one of our finest diagnosticians on that very point.

He sent in a woman for stomach examination because he suspected that a previous X-ray study done elsewhere in the state had been inaccurate. As was my habit then, I sent the report to him and not to the patient. But a few days later the woman appeared at the department, saying that she wanted to ask me some questions not about treatment or diagnosis but about the X-ray examination we had made as compared with the earlier one she had had. Feeling that this was a chance to show an intelligent person the difference between a properly done X-ray study and a poor one, I talked with her for some time and tried to explain what we had done and why we had done it in a particular way. When she went away she thanked me and said she was much better satisfied about the whole matter.

But two days later her doctor came storming in to upbraid me for having talked with her at all. To his way of thinking I should have refused to see her and should have sent her back to him at once. My assurance that I had not mentioned his work or the treatment he had prescribed did not placate him. He accused me of unprofessional conduct and threatened to bring the affair before the hospital staff and the country medical society and vowed that he would never send another patient to the X-ray department while I was there. Being relatively young and a rather recent arrival in the city, I was disturbed by his attitude; that he was honest in his views I had no doubt and I dreaded his influence with the other men on the hospital staff. But in due time he concluded that I was less untrustworthy than he had at first thought me and began to send in patients again.

In spite of unpleasant experiences like this I continue to believe that in many cases the roentgenologist can explain his findings to the patient more satisfactorily than anyone else. If he is to do this, the chief requisites are an ability to put his meaning into non-technical language which a lay person can understand and a willingness to take the necessary time and to pull away the veil of secrecy which still conceals much of medical procedure. To my mind, nothing but good results from this practice, and this opinion has been confirmed by experience notwithstanding a few disagreeable episodes.

There is still another group of patients who might with advantage go directly to the radiologist. They are the persons who have or think they have cancer and are so terrified by the prospect of surgery that they will not consult the ordinary doctor. These people are much less reluctant to see a radiologist. Their disease is often far advanced and in these cases radiation frequently offers a better prospect than operation. After they have improved under treatment with radium and X rays they can usually be persuaded to submit to examination by a surgeon if that seems advisable. Certainly the radiologist has here an opportunity for great service.

RADIOLOGICAL SERVICE IN THE UNITED STATES

There is not enough expert radiological service available in this country. Part of this is unavoidable, part of it is due to the attitude of hospital administrators and the medical profession, and part of it is the result of commercial exploitation by big business.

The registry of the American Medical Association lists over 6,300 hospitals. Besides this there are several hundred small institutions and nursing homes which cannot meet the minimum standards set up by this body. As soon as we find that there are not 2,500 fully trained radiologists in the country, it becomes clear that only a fraction of our hospitals have qualified men doing their radiological work. There are simply not enough to go around.

Almost as serious is the fact that much X-ray work is done not in hospitals or by specialists but in the offices of physicians. It is true that in small towns there is often no way to get even the simplest roentgenological examinations made unless the local doctor buys his own machine, and it is also true that many physicians use X rays only in their fracture cases while many others have taken special training and are thoroughly competent to make X-ray studies in their own fields. But glib salesmen of manufacturers of X-ray apparatus persuade many doctors that both their prestige and their income will increase with the addition of X-ray machinery to their office equipment. And we all know that any physician can buy this apparatus and begin to use it whether he knows how to do so or not.

People have come to believe, quite rightly, that every fracture should be X-rayed and some doctors get their machines only for that reason, but once they have been installed, temptation arises to use them for other purposes also. It is so easy to say to a patient who presents confusing symptoms, "We'll just X-ray your chest and see if there's anything wrong" or "Come in tomorrow morning without your breakfast and I'll have a look at your stomach." The result is that many X-ray examinations are made by men who have had no training in this work and with machines of too small capacity to handle properly the load put upon them. The outcome is both that important diagnoses are missed and that people are told they have diseases which they actually do not have. Part of this confusion stems from the poor technical quality of the films made and part from the incapacity of the doctor to understand what he sees on the fluoroscopic screen or the roentgenogram. But in either case the patient has been let down.

I found this out a good many years ago. I graduated from medical school with no practical knowledge of X rays except in the simplest fractures. When I had been practicing for some four years it fell to my lot to do the X-ray work in one of the small substandard hospitals I have been speaking about. I was enthusiastic about the job and anxious to do it well, but I knew almost nothing about it. Not long after I took over the primitive machinery and even more primitive darkroom, a man was sent up by one of the doctors in town for a chest plate. I made the exposure and developed the film well enough, but when we came to look at it neither the referring physician nor I knew what to think. It looked spotty to me then and I know now that it showed a widespread tuberculosis of the lungs, but in 1921 I did not realize that. I never knew exactly what the doctor told his patient but in a week or two I heard that the man had left town.

If you can put yourself in my place—an eager, conscientious but scarcely half-baked physician—you will understand how I felt when a year later I came upon that patient in a tuberculosis hospital—a far advanced, almost hopeless case.

I think the realization of my complete ignorance brought home to me by this experience had a good deal to do with my later decision to make a roentgenologist out of myself.

Some radiologists have gone into communities where there was no X-ray laboratory, sunk thousands of borrowed dollars in equipment and office rent, only to lose everything except their shirts because the doctors in those communities insisted on doing their own X-ray work in their offices instead of sending the patients to the specialist. Sometimes, made desperate by such a situation, these men have tried to build up practices and clientele of their own, only to be labeled unethical and treated to heated lectures on the enormity of a radiologist's having any patients except those referred by other practicing physicians. Sometimes, having caught one of the amateur roentgenologists in a blunder which could only be caused by gross ignorance, the radiologist has been threatened with persecution should he divulge the mistake or consent to bear witness in a malpractice suit and exhorted to uphold the unity of the profession and its place in the community. And, for the most part, these men have kept the peace—now because they were afraid not to, and again because they were too tired to fight or saw too little prospect of success.

There is practically no chance of earning a living and a meager return on invested capital if a man opens a radiological laboratory in an area with less than fifty thousand tributary population. If there are fewer people than that to draw from, there will not be enough referred work from other doctors to keep going. Many physicians with small machines in their own offices are a menace. Usually they know only what the equipment salesman has taught them. In most cases their office nurse or a girl fresh from high school who needs a job makes the films and does the darkroom work. Almost without exception these girls are totally devoid of knowledge of or interest in radiology. They know little about the safety which lies in distance and filters and are so ignorant of chemistry that they do not cover their developing solution when it is not in use, or keep it below 72 degrees Fahrenheit, or make it up fresh more than twice a year. They do not wash the screens in the casettes, or dust the machine. And yet their employers attempt to make X-ray diagnoses. That this is no exaggeration, every alert radiologist knows very well.

Another type of difficulty besets the man who operates the radiological department of a hospital on a salary or percentage basis. He becomes for all practical purposes an employee of the institution and thereby endangers his professional standards. These last thirteen or fourteen years hospitals have had a bitter struggle to keep out of the red, and the X-ray laboratory is one department which usually takes in a good deal of money in an institution of any size. Hence hospital superintendents may try to set the charges for radiological work at a level they believe will bring in the largest possible revenue and at the same time cut down the expense of the examinations to the minimum. Many of us have been called on the carpet like menials because we used up too many films in the superintendent's opinion, or because we were not properly solicitous over a patient who was also a member of a trustee's family or even a trustee himself. Many of us have had to do battle to get needed new equipment, to get old apparatus repaired, to get new tubes of improved design, to get a darkroom large enough to work in efficiently, to get enough time off for our technicians to maintain their health, to get enough radium to treat adequately the patients in whom it is indicated. And inevitably some of us have turned sour in this struggle for the means wherewith to do our work well and have come to think of hospital administrators as our natural enemies.

In many localities where there are only small twenty-five to fifty bed hospitals, there is no X-ray service worth the name. A handful of doctors will have machines in their offices—operated for the most part by an office girl—and the hospital will probably have antiquated or poorly chosen equipment fit to do nothing more than make films of arms and legs, in charge of a technician who has had from three to six months of training at most. The interpretation of films will be left to the individual physicians. To their everlasting credit be it said that many of these men learn a great deal about roentgenology, but all too often they never recognize their inability to understand what the films show.

How to keep radiology out of the hands of technicians who know nothing of its medical implications and out of the hands of doctors without training in this specialty is a problem which baffles us all. Professional ethics prevents us from calling attention openly to one another's deficiencies or to special training and abilities. Every physician who has an X-ray machine in his office is free to announce that fact on his office door, thus making his patients believe that he is qualified to do X-ray work. No hospital dare call attention to the fact that it has better equipment and a more highly qualified radiologist than its competitors, because hospitals are supposed not to compete with each other or with physicians.

The general public has too little interest and is too ill-informed to solve this problem. The politicians who dabble in the social sciences and services would very likely make a bad matter worse by shortsighted laws and inflexible classifications. The medical profession is too confused in its own thinking and too inept at adjusting to changing social conditions to approach the question calmly, discuss it frankly and dispassionately, and come to a clear-cut decision.

And hospital administrators for the most part have the viewpoint of business rather than that of a profession.

Perhaps nothing will avail except individual integrity. If no medical man would undertake any procedure he had not made himself competent to do in a workmanlike way, if no doctor ever referred a patient to another physician without first making sure of that man's training and ability and standards of conduct, if none of us would consent to take patients into any hospital where we would not be glad to take our own families—perhaps we would be rid of some of our dilemmas.

We know how to feed and clothe and house great multitudes properly and how to give them good medical service, but we never do it except when we are at war. As soon as peace comes, we relapse into our old ways of irresponsibility and indifference. We know better than we do. We dignify this lapse by calling it a "cultural lag."

Our knowledge of the medical sciences has outrun our knowledge of the art of practicing medicine, and both have outrun our methods of distributing medical service. On the one hand we have millions of people who cannot afford the attention of a doctor or a dentist and other millions who do not even know they need this care, and on the other hand we have some 152,000 physicians in private practice few of whom are fully employed in peacetime and many of whom have incomes so small that they cannot live without anxiety, cannot keep abreast of professional progress, cannot afford the instruments of modern scientific medicine. And between the two there is a great gulf fixed.

If this is to be in fact "the century of the common man," we have much to do. After we have won our war against the Axis, we shall have another war to fight—a war against pestilence and the death it brings. The weapons science has forged for us are at hand, but we have not yet learned to use them for the benefit of that mass of men who are now called upon to battle for our way of life. That way of life must be made to render to the common man more happiness, greater security, and better health before it is worth the sacrifice he is making for it.

Glossary

ACNE: a chronic disease of the skin, common among adolescents and young adults.

ALPHA RAY: a large particle thrown off by certain radioactive atoms.

ANEMIA: state in which red cells and hemoglobin of blood are below normal.

ANESTHETIST: person who gives a patient an anesthetic.

ÅNGSTROM UNIT: unit of measurement for ultraviolet. Abbreviated Å.U. One ten-millionth of a millimeter.

ANEURYSM: dilatation of the aorta.

AORTA: the great artery leaving the heart.

APICES: uppermost portions; used especially in regard to the lungs.

ARTERIOSCLEROSIS: stiffening and thickening of artery walls.

ASPHYXIATED: deprived of air.

ATELECTASIS: airlessness; containing little or no air.

AUTOPSY: examination of a body to determine the cause of death; post-mortem.

AVITAMINOSIS: state of malnutrition due to absence of all vitamins from diet.

AXILLA: armpit.

BARIUM: chemical opaque to X rays, widely used in X-ray examination of digestive organs.

BETA RAYS: streams of electrons ejected by radioactive atoms.

BILE: a secretion of the liver.

BLOOD CHEMISTRY: quantitative examination of blood for certain chemical substances present or increased in disease.

BLOOD COUNT: enumeration of the red and/or white cells in 1 cubic millimeter of blood.

BRONCHIECTASIS: a chronic non-tuberculous infection of the bronchial tubes.

BRONCHOSCOPE: instrument with which one can look down into the bronchial tubes.

BRONCHUS: a bronchial tube.

CALCULI: stones, mineral deposits.

CANCER: a malignant tumor. (Not a scientific term.)

CARCINOMA: a common type of malignant tumor.

CARBON ARC: a type of lamp which emits many ultraviolet rays.

CASSETTE: receptacle in which x-ray film is put before exposure.

Cecum: first portion of colon, or large bowel.

CEREBRAL HEMORRAGE: hemorrage into the brain; a "stroke."

CERVIX: the mouth of the uterus.

CHOLECYSTOGRAPHY: x-ray examination of the gall bladder.

CLAVICLE: collarbone.

COLON: the large bowel.

COLITIS: an inflammation of the large bowel, often of emotional origin.

CONNECTIVE TISSUE: framework, or supporting tissue; e.g. bone and cartilage.

CONGENITAL: existing at the time of birth.

CORTEX: outermost layer.

CROSS-FIRING: method of directing beams of radiation from various angles so as to intersect at a chosen point.

CYST: a hollow tumor containing fluid.

CYSTOSCOPE: an instrument inserted into bladder through which the interior of that organ can be seen and treated.

DEVELOPER: solution in which x-ray films are developed.

DIAGNOSIS: statement of disease from which a patient is suffering.

DIAPHRAGM: partition between thorax and abdomen.

DIVERTICULUM: an abnormal pouch, extending out from a hollow organ.

DUODENUM: first portion of small intestine beyond the stomach.

DYSPNOEA: difficulty in breathing.

EMPYEMA: collection of pus in thorax, between lung and chest wall.

ENCEPHALOGRAPHY: method of examining the brain with X rays, in which air is injected into the spinal canal before films are made.

ERYSIPELAS: an acute infection of the skin usually caused by a streptococcus.

ESOPHAGUS: tube leading from throat to stomach.

EXHALE: breathe out.

FEMUR: thighbone.

FETUS: embryo; unborn child.

FIBROID: a common nonmalignant tumor of the uterus.

FLUORESCE: to glow in a beam of X rays or ultraviolet, in a darkened room.

FLUORESCENT: shining in a beam of X rays or ultraviolet, in a darkened room.

FLUOROSCOPE: apparatus with which roentgenologist observes on a fluorescent screen certain organs of the body in action—e.g. the stomach.

FLUOROSCOPY: examination by means of the fluoroscope.

GAMMA RAYS: super-X rays given off by certain radioactive atoms.

GENERATOR: machine which manufactures electric current.

HELIOTHERAPY: treatment with sunshine.

HEMOGLOBIN: red coloring matter of the blood.

HODGKIN'S DISEASE: a type of malignancy in which the lymph glands are much enlarged.

HYPERPERISTALSIS: overactive peristalsis.

HYPO: solution in which X-ray films are fixed or cleared, after having been developed.

INHALE: to draw in one's breath.

KELOID: a thick elevated livid scar.

LESION: a disease process; a diseased or injured area or region.

MALIGNANCY: a synonym for cancer; a malignant tumor.
MALIGNANT: as applied in medicine, a disease so dangerous as often to cause death; specifically, referring to or connected with tumors of the cancer family.
MALINGERER: a person who pretends to be ill when he is not.
MERCURY VAPOR LAMP: a type of lamp emitting ultraviolet rays.
METASTASES: daughter or secondary cancers.
METASTASIZE: to spread over the body through the blood or lymph vessels.
MILIARY TUBERCULOSIS: generalized tuberculosis which has spread into many organs.
MULTIPLE MYELOMA: a malignant tumor of bone.

NECROTIC: decaying; broken down by infection.
NEPHRITIS: an acute infection of the kidney; a chronic type of degeneration of the kidney known sometimes as Bright's disease.

OB: short for obstetrics.
OBSTETRICS: science of childbirth.
OSTEOMYELITIS: infection of bone; usually non-tuberculous infection is meant.

PATHOLOGIST: a physician who does laboratory work and studies tissues under the microscope in order to diagnose disease.
PEDIATRICIAN: a specialist in the care and treatment of children.
PERIOSTEUM: membrane covering bones on the outside.
PERISTALSIS: waves of muscular contraction in the muscular walls of the stomach and intestine.
PITUITARY: a gland near the base of the brain which has much to do in regulating growth and sexual development.

POST-MORTEM: an autopsy; examination of a body to determine the cause of death.

PNEUMOCOCCI: the germs which cause pneumonia. There are now thirty-two known types.

PRIMARY: as applied to tumor, the first to appear; the original tumor.

PROSTATE: a gland found at the outlet of the bladder in the male.

PULMONARY: of or pertaining to the lungs.

PYELOGRAPHY: X-ray examination of the kidneys and ureters after filling them with a substance which will cast a shadow on X-ray films.

PYLORUS: the opening between the stomach and the first portion of the small intestine (duodenum).

"R": designation of the unit of radiation delivered by the X-ray tube.

RADIOLOGIST: a specialist in the use of X rays, radium, and ultra-violet.

RADON: the gas emitted by radium when in dilute acid solution.

RICKETS: a disease of children caused by deficiency of vitamin D in the diet.

ROENTGENOGRAM: an X-ray photograph.

ROENTGENOLOGIST: a specialist in the use of X rays.

SARCOMA: a malignant tumor arising from bone or connective tissue cells.

SCIATICA: an affection of the sciatic nerve, in the back of the thigh.

SCRUB UP WITH: assist a surgeon in some operative procedure.

SCURVY: a disease caused by deficiency of vitamin C in the diet.

Sella turcica: niche in the floor of the skull occupied by pituitary gland.

SILICOSIS: a dust disease of the lungs caused by inhaling fine particles of silica; "miners' consumption."

SINUS: drainage tract; air-space in certain hollow bones of the skull.