This is clearly seen in Table VII, and in Table VI it is also seen, though in some experiments more paramoecia pass into the tubes containing acid than into the control tubes. (Compare also Table VIII.) At first I regarded the latter as evidence of a true positive chemiotaxis, but subsequently I found myself compelled to abandon this view, since further experiments showed that the tendency to pass into tubes containing acids in greater numbers than into control tubes was not a constant, but merely an occasional, feature of such experiments, and that if several experiments are averaged, the number of paramoecia entering tubes containing acids is less than that entering the control tubes. A somewhat similar feature is exhibited in Table VII. Here it is seen that the number of paramoecia entering tubes of distilled water is in most experiments less than that entering tubes of hay infusion, the former being on the average only about one quarter as numerous as the latter; but four exceptions occur, namely, Experiments 1, 15, 19, 31, in which the number of paramoecia entering amounted to respectively 135 per cent., 108 per cent., 143 per cent., and 108 per cent. of those passing into the control tubes. A two-fold variability is inseparable from experiments on chemiotaxis: first, the variability in successive experiments, partly due to change in the condition of the paramoecia, which unfortunately cannot be kept constant from day to day, or even from hour to hour, and partly to the next factor; secondly, variations involving the individual tubes employed in the same experiment, attributable to undetected variations in the conditions of experiment. The chance of the latter occurring is obviously greater the weaker the concentration employed; if hyper-lethal concentrations are used strong negative chemiotaxis is alone observed. The variability which is present in successive experiments places a difficulty in the way of determining the relative influence of individual acids and alkalies upon paramoecia. From the single experiments given in Tables VI and VII no conclusion can be drawn. A comparison of the chemiotaxis of acids and alkalies in equilethal concentration in respect of paramoecia in distilled water (cf. Table VIII), however, shows that the latter are more negatively chemiotactic than the former. In equi-molecular concentration this difference is no longer marked.

In all experiments on the chemiotaxis of paramoecia a difference of osmotic pressure comes into play, to which in part the phenomena of chemiotaxis are due.[29] This occurs, for example, in the experiments recorded in Table VII, in which the paramoecia were immersed in hay infusion. If the paramoecia passing into the tubes containing distilled water are compared with those passing into acid and alkali, it is seen that the latter are less than the former for the stronger concentrations, but that the difference is inconsiderable with the weaker concentrations. In these experiments obviously difference of osmotic pressure plays a share in the taxis noted. In Table VI the difference of concentration, that is, of osmotic pressure, is greater for the stronger alkalies than for the stronger acids, and the chemiotaxis is also greater, but the difference of concentration is less than that between hay infusion and water. In practice, however, since it is as yet impossible to separate the physico-chemical from the purely chemical effect of acids and alkalies, the term chemiotaxis must be understood to include both, and whenever the composition of the fluid to be tested is stated, the characters of the liquid in which the paramoecia are contained should also be given.

The foregoing observations may be summarized as follows:

1. Paramoecia pass readily into tubes containing acid and alkaline solutions of sublethal concentration, but pass still more readily into control tubes containing the same liquid as that in which the paramoecia are immersed.

2. Only negative chemiotaxis appears to be exerted by acids and alkalies upon paramoecia. This negative chemiotaxis is marked in alkaline solutions of lethal concentration, and is slighter in acid solutions of lethal concentration.

3. There is no parallelism between (*a*) the lethal concentration of acids and alkalies for paramoecia, and (*b*) the chemiotaxis of paramoecia in respect of acids and alkalies.

4. The taxis of paramoecia is modified when these organisms are transferred from hay infusion to distilled water.

5. Chemiotaxis is not to be explained simply by reference to the acidity or alkalinity of the solutions employed. Mere change of concentration is an important factor in its production.

6. Negative chemiotaxis does not necessarily indicate that the liquid tested acts injuriously upon the organisms employed.

In conclusion, I must express my indebtedness to Professor Verworn, in whose laboratory the above research was conducted; to Professor Nernst, who kindly permitted me to make the physical measurements in the Physiko-chemisches Institut in Göttingen, and also to Professor Coehn, at whose suggestion palladium-hydrogen electrodes were employed.

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THE DIAGNOSTIC VALUE OF X RAYS.*

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TEN years have passed since *x* rays came into use in medical and surgical work, but there are many who do not yet realize the proper way of employing them, or their necessary limitations.

In this connexion, the main point I wish to urge is the importance of always taking *x*-ray photographs stereoscopically. Some slides will be thrown upon the screen to illustrate this point, as also some stereoscopic transparencies.

An *x*-ray photograph produced by a good focus tube is often so clear that it is not easy to realize that it is only a shadow of the object which was interposed between the tube and the plate, and that the apparent relative positions of the parts by no means represent the actual positions.

In the BRITISH MEDICAL JOURNAL of January 1st, 1898, however, I described a method of precise localization; and again, on December 3rd, 1899, I published an illustrated article on *x*-ray stereoscopy. Later I applied my method of localization to ophthalmic work, and found that the position of exceedingly minute particles of metal or glass can be determined in the eyeball or orbit to the $\frac{1}{50}$th of an inch. Several cases of this kind are reported in the *Transactions of the Ophthalmological Society of the United Kingdom.*

I regret that this communication is the last one on the

* Read before the Section of Medicine at the Annual Meeting at Leicester, July 28th, 1905.

last day of the Meeting. Had it been earlier, members interested would have had an opportunity of studying several stereoscopic photographs which would have been placed on view; as it is, only those present now will be able to verify my statements by actual observation.

I will at once proceed to describe some cases which will illustrate the diagnostic value of *x* rays.

RENAL CASES.

The symptoms in these are often very puzzling, and it is important to decide, if possible, not only if a stone be present, but also to determine its size and position.

This first slide shows a variety of calculi and shows how they vary in opacity to *x* rays. The opacity of a substance is in proportion to its atomic weight. If the chemical composition of a calculus is known, then its relative opacity is known. The heavier the atom the more opaque it is to *x* rays—hence gold, lead, platinum and bismuth are all very impenetrable. Aluminium, owing to the very light weight of its atom, is very transparent. Carbon, hydrogen, oxygen, and nitrogen, of which our bodies are chiefly composed, are very transparent. The phosphorus and calcium in bones account for their showing so well in contrast with skin and muscle.

Uric acid and urate of ammonia calculi are almost as transparent as flesh, as can be seen by contrasting the difference between them and the hand—whereas oxylate of lime, phosphate of lime, and even a cystic oxide calculus are fairly opaque, owing to the sulphur atom weighing 32 in it. It is quite likely, therefore, that a small uric acid calculus in a stout patient cannot be differentiated by *x* rays and so may escape detection. Slides of cases will now be thrown upon the screen.

CASE I.

The first case is that of a lady, Mrs. M., who for some years suffered from rather obscure symptoms, and had had many consultations and many diverse opinions. Her kidneys had been *x*-rayed, and nothing found. I also *x*-rayed her kidney region, and found nothing abnormal; but when I photographed her pelvis I found two stones, one above the other, and almost in contact in her right ureter. They do not show very clearly in this slide, but if you will look at the stereoscopic slide reduced you will be able to see them unmistakably, and following the bend of the ureter in the region in which they are situated. These were not only localized precisely, but the exact size of each was estimated and proved correct when they were removed by the late Mr. Allingham—a brilliant operator whose untimely death we all deplore. A good recovery ensued, but later on pain, etc., recurred. I made another *x*-ray examination, and this time found the ureters free, but a large stone in the right kidney which previously I had failed to detect. It is likely that the removal of the stones in the ureter altered the physical conditions, and made it possible for the *x* rays to reveal it. This stone was removed, followed by a good recovery; but pain and large quantities of pus were passed. Finally, the kidney was removed, and now the patient is quite well. It would, of course, have been best to remove the kidney in the first instance; but the next slide is of a case in marked contrast to this one, and well illustrates the value of conservative surgery.

CASE II.

Mr. P., sent to me by Mr. Edward Ward of Leeds. The history shortly is as follows: A large stone, almost a complete cast of the pelvis of the right kidney, and many small ones, were removed by Mr. Ward. Indeed the tissue seemed so much damaged that he nearly removed the kidney itself. This, fortunately, he did not do, because some time afterwards his left kidney became inflamed and Mr. Ward incised it for pyonephrosis, and the haemorrhage was so terrific that no search for a stone at the time was possible. On July 28th, 1903, *x* rays show the kidneys free from calculus but a small one is shown in the left ureter, close to the bladder. I strongly urged him to be *x*-rayed again later on before returning to his surgeon (as he was going South for a holiday). On August 31st, 1903, the stone had passed into the bladder as shown in the adjacent picture. Mr. Edward Ward crushed it and the patient is now well.

CASE III.

Mr. D. Had stones removed from the bladder suprapubically. No relief. Symptoms extended over twenty-five years, and several opinions obtained—"atony of the bladder," "vesical tumour," etc.; *x* rays cleared up the diagnosis as I found a large stone, 34 mm. long by 19 mm. broad, in the ureter, just as it entered the bladder. Sir William Bennett removed it successfully suprapubically.

CASE IV.

Mr. M. D. This gentleman suffered from obscure renal symptoms for over twenty years. Had had consultations with the celebrated surgeons, Butcher of Dublin, and Sir Henry Thompson. Finally Mr. Hurry Fenwick sent him to me and here you observe a huge stone in his ureter, which Mr. Fenwick removed with complete success.

CASE V.

C. D. This is an unfortunate case, sent to me after a sudden typical attack of real colic on his right side, with a request to examine his kidneys. This was done. Negative result, except that in the right side (the affected one) there was a vague degree of diffuse opacity in the kidney region as compared with the sound left side. On photographing his ureter and bladder regions you will observe the result on the screen. There is a curved opaque mass in the position of his right ureter; in fact, it may well be a kink in the ureter loaded with débris. On consultation with his physician, who examined the negatives with me, it was agreed that the opacity was probably in the ureter close to the bladder, and that as all acute symptoms had subsided he had better take Contrexéville or other waters, and be *x*-rayed again in about six weeks. I went abroad immediately afterwards, and on my return in a fortnight was surprised to find that just after I left a surgeon had been consulted, who, contrary to the physician's wish, operated immediately. It appears he opened the kidney, and believes he passed a probe into the bladder, and declared that there was nothing in the ureter; suppuration and thrombosis followed. The patient refused to be *x*-rayed again, and now declares that *x* rays produced, to quote his own phrases, a "false photograph" and a "photograph of something that never existed," and "was the cause of all his misfortunes."

This case well illustrates the importance of caution on the part of surgeons, and the advisability of careful consultation with their colleagues who devote their time specially to *x*-ray work. To make an incision several inches away from the part where *x* rays reveal the presence of an abnormality is hardly wise, and certainly unfair to *x* rays. The stereoscopic picture (reproduced in plate) in this case absolutely proves that the opacity is either in the right ureter near the bladder, or in its immediate neighbourhood. Of course, if the operation was to be done at all (and in this case it should have been delayed) it should have been performed like the one in Case II, in which the two stones were removed successfully from the ureter in a few minutes.

CASE VI.

Miss S. This case, sent to me by Mr. Hurry Fenwick, had opacities shown, some of which might have been in the ureters, and so I suggested to Mr. Fenwick to catheterize the ureters, either with a wire inside the catheter or with a catheter made with any suitable material of heavy atomic weight added—such as antimony which is used in ordinary red rubber tubing. You see the result in this slide. The opaque bodies are free from the ureters, and proved to be tuberculous glands. The outline of the bladder is here well shown by its being filled with air. I wish to call your attention to a stereoscopic slide—which you can view afterwards—where a small opacity was located as either in the ureter or immediately adjacent. Mr. Fenwick catheterized it, and on photographing it it was clearly seen to be outside the ureter, but immediately adjacent to it. It proved to be a patch of atheroma on an artery. These two cases have been illustrated recently in a paper by Mr. Fenwick in the BRITISH MEDICAL JOURNAL.

CASE VII.

Mr. B. Sent to me by Mr. Watson Cheyne. His kidney had been opened for pyonephrosis six years ago. He now has a large fistula, and has to wear a portable urinal, a large tube being worn in his side into the kidney. The cause of this is seen in the large calculus in the ureter higher up than usual.

In this connexion I should like to mention a very instructive case of Captain G. This gentleman in February, 1901, was just on the eve of having his kidney explored when Sir Dyce Duckworth and Dr. Guthrie Rankin thought it advisable to have him examined by means of *x* rays. I could find no stone in his kidney, but in his ureter on the affected side I found three very small calculi like beads, with an interval of about ½ in. between each, one was quite close to the bladder. The operation was abandoned and he went to Contrexéville, passed the three stones, and has been quite well ever since.

CASE VIII.

Dr. H. This gentleman had been operated on some time ago for supposed stricture of the urethra with indifferent success. Mr. Reginald Harrison felt a stone in the prostate; he sent him to me, and two were revealed as shown in the slide, and Mr. Harrison successfully removed them.

MISCELLANEOUS CASES.

CASE I.

This slide shows a large aneurysm of the aorta. Screen examination is most useful in these cases, and during bright weather the only satisfactory way to do this is to have a small absolutely dark tent, inside of which the observer should be in total darkness for at least ten minutes, so as to allow the retina to accommodate itself to the perception of the shadows cast on the fluorescent screen, which is placed against one side of this tent. This plan has the additional advantage of allowing all the manipulation of the apparatus, etc., to be done in the light.

CASE II.

Dr. Dundas Grant brought this patient, who had a diverticulum in her oesophagus. We observed her swallow bismuth emulsion by means of the screen; most of it went down the oesophagus, but some of it ran into a small oesophageal pouch shown in the slide. It has been successfully removed by Dr. Dundas Grant.

CASE III.

Another case of Dr. Dundas Grant's showing probing of the frontal sinuses from the nose. Lateral view and front view are shown.

CASE IV.

Case of Master H. Subdiaphragmatic abscess, right side. Screen examination showed right side of diaphragm immobile on respiration, and bulged upwards. Stereoscopically showed a bulging cone in the middle of diaphragm; operation: ninth rib resected, abscess found and drained. Complete recovery.

CASE V.

Lord F. shows a shot in orbit after having injured eyeball in transit. Eyeball was therefore not enucleated.

CASE VI.

Half the portal vein injected shows that vascularly the liver is divided into two halves. Mr. James Cantlie held this opinion, and he injected and brought this specimen, which fully confirms his view.

CASE VII.

A young girl, aged 16, had congenital dislocation of the hip-joint. She went to Vienna, and was operated on; on her return I again photographed her; result showed the same condition, except that the epiphysis of the head of the femur has been injured. The mother was assured that the operation had improved the condition greatly, and, on inquiring if they did not use x rays to verify their results, she was informed that they were quite unnecessary. The pictures speak for themselves, comment is quite unnecessary.

I trust that these cases are sufficient to illustrate the great diagnostic value of x rays, but to make an accurate and reliable diagnosis it is necessary for the physicians and surgeons to work together with their colleagues who devote themselves to x-ray research.

Quite recently an interesting case has come under my observation, which so well illustrates the value of x rays as an aid to diagnosis that, with the permission of the Editor, a short account of it is here added. For the notes of the case I am indebted to Dr. Parkinson.

Mr. P., aged 54, was under treatment by Sir Patrick Manson for several months previous to June 1st, 1905, for malaria, from which he had suffered twenty years ago in India. In May he found himself losing weight and energy and suffering from frequent rises in temperature in the evenings. He was treated for malaria and rheumatism, but did not improve. When examined on June 1st he had pains shooting down both legs, pain in sacro-iliac joint in the evenings, along crest of ilium and along the seventh intercostal space. There was no tenderness in the kidneys, but recurrent lumbago. The urine was examined frequently and found normal. He did not improve under treatment, and was sent to Buxton towards the end of June by advice of Sir Hermann Weber.

At Buxton no improvement took place, and he soon began to suffer more lumbar pain, the temperature rising every night and profuse perspirations following, and his strength and weight began to fall rapidly. While at Buxton there were three consultations with London physicians, the diagnosis being "malaria with rheumatism" and "acute lumbago associated with endocarditis." He was brought to London six weeks ago, much emaciated and apparently in a critical condition. The pain became exceedingly severe. Sir Patrick Manson requested me to make an x-ray examination to ascertain if it could throw any light upon the case. I found the patient looking ill and dreading the paroxysms of pain. His chart showed an evening temperature of 103°.

X-ray negatives were taken of the chest, abdomen and pelvis, and nothing abnormal was shown except a distinct opacity in the left kidney region. A consultation with Sir Thomas Barlow, Sir Patrick Manson, and myself took place. The clinical symptoms did not in any way confirm the x-ray diagnosis, and so it was decided to repeat the x-ray examination next day. The same result followed: an opacity exactly like a renal calculus appeared in all the negatives in the left kidney region. It was arranged that Mr. Godlee, in spite of absence of clinical symptoms, should explore this region. This was done, and a small cyst was found in the left kidney, which was evacuated, and then the whole kidney was excised on account of malignant disease. There was a stone in its centre, or possibly a degeneration of the tumour. (The specimen has not yet been properly examined and reported upon.)

This case well shows the value of x rays even in cases where their use seems likely to be of little or no service.

LEAD POISONING FROM ELECTROLYSIS OF WATER PIPES.

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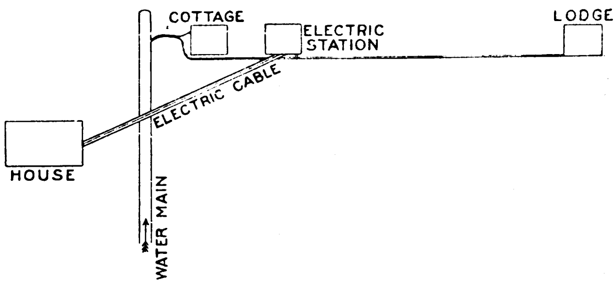
A FEW months ago I was called to see a man who was suffering from unmistakable signs of lead poisoning. This was found to be caused by the water which he was drinking, which contained 0.14 gr. lead to the gallon.

The water is supplied by a water company to a very large area. It is of great organic purity, and is obtained from a deep well in the chalk. The total hardness is reduced from about 14° to 6°. In every instance the service pipes are of lead, and the water has never before been known to attack them so as injuriously to affect the water. It was noticed that the water from the tap at the cottage was slightly turbid, whereas normally it is quite bright.

A piece of the lead service pipe was cut out near the cottage and examined. On the interior could be seen patchy lumps of what proved to be lead carbonate. The lumps projected about ⅛ in. above the internal surface of the pipe, and could be easily brushed off with the finger as a white powder. No doubt the turbidity of the water was due to this powder in suspension.



The cottage was the entrance lodge to a large house situated some 200 yards away, and midway between the two was an electric-light station which supplied the house but not the lodge. It was thought by the water company's consulting engineer that the lead in the water was due to electrolysis, caused by a leak from the electric cable.

The water main is situated in a road between the large house and the electric station. From the main a lead service pipe about 150 yards long supplies the lodge, and on its way branches to the electric station, and to another cottage close to it. The pipe from the main to the electric station was put in two years ago, but it was only continued to the lodge six months since.

The electric current is supplied to the house by means of an insulated positive main and an uninsulated copper strip return; the latter is supposed to be earthed at each end, but both are enclosed in a wooden trough and embedded in bitumen. The cable passes about 18 in. above the old portion of the service pipe near the electric station. After numerous tests by a firm of electricians employed by the company a leak of 1.8 volts was discovered, and this in their opinion was sufficient to cause the electrolysis.

The lead service pipe was examined at various points, and was found to be most affected near the lodge, whereas

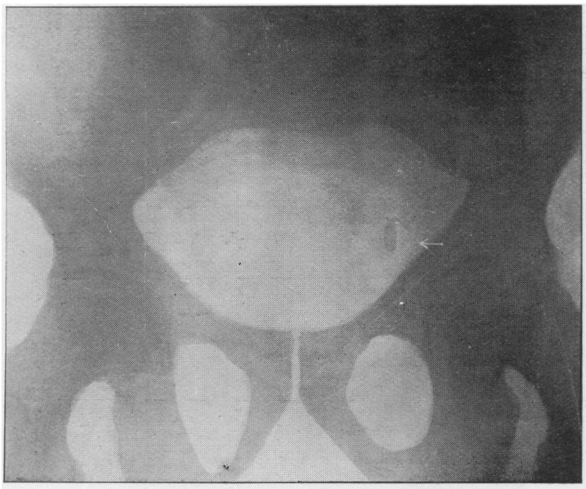


Fig. 1.—Case II (*a*). Small stone in ureter.

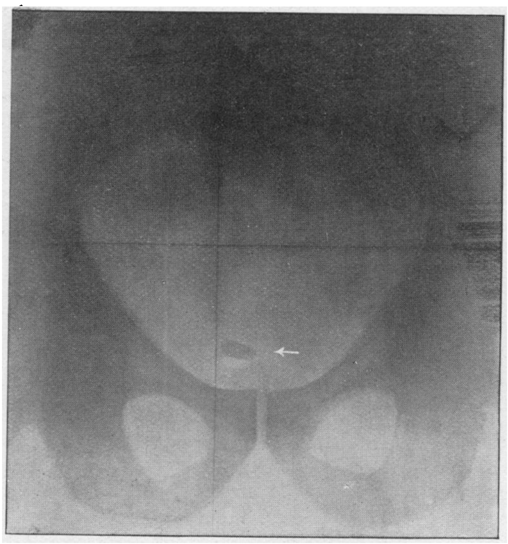


Fig. 2.—Case II (*b*). Stone has passed down into the bladder.

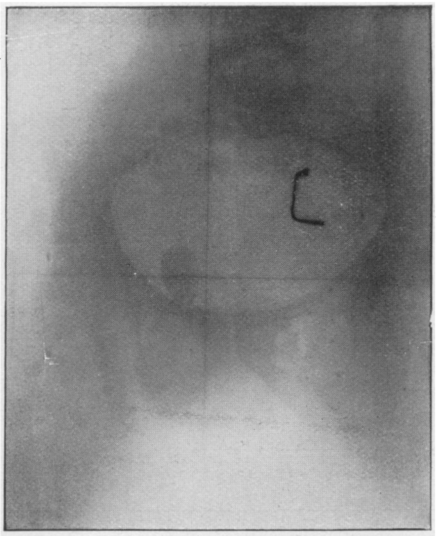


Fig. 3.—Case III. Large stone in lower end of ureter.

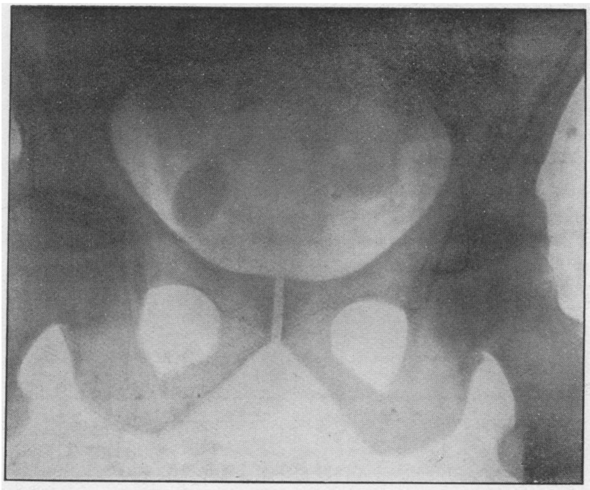


Fig 4.—Case IV Large stone in ureter.

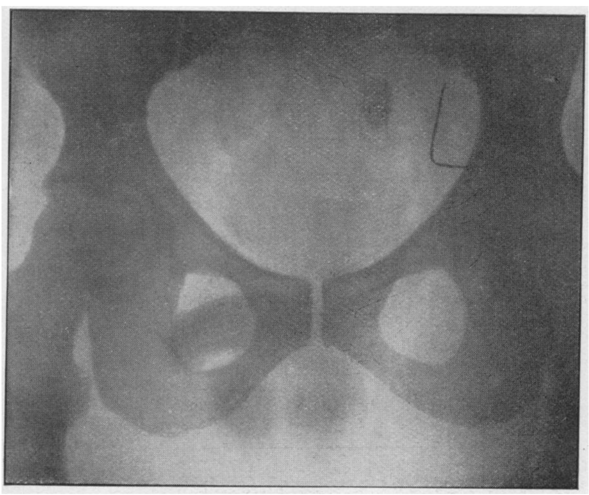


Fig. 6.—Case VII. Large stone in left ureter.

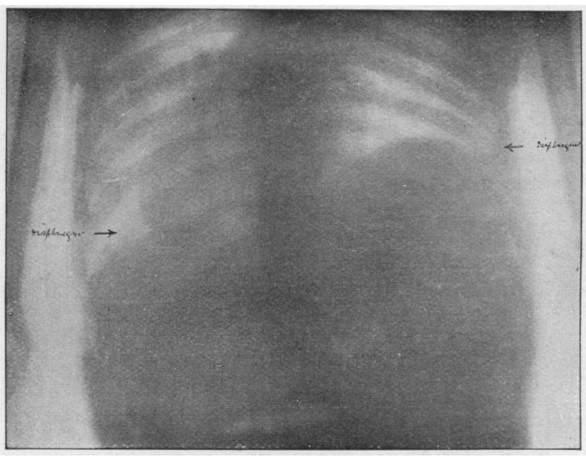


Fig. 7.—Subdiaphragmatic abscess, right side.

TO ILLUSTRATE MR. J. MACKENZIE DAVIDSON'S PAPER.

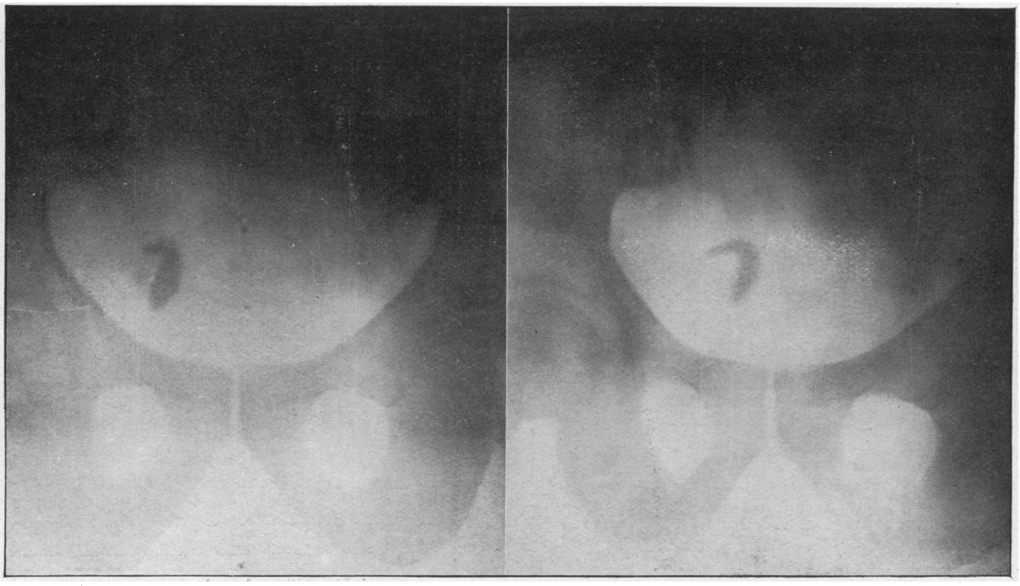


Fig. 5.—Case V. Stereoscopic photograph; should be viewed with a lenticular stereoscope.

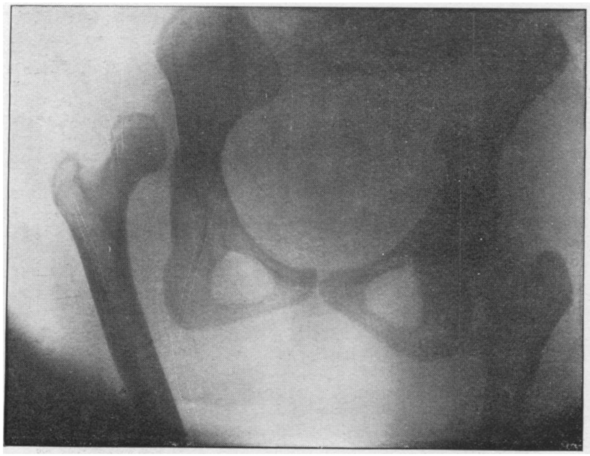


Fig. 8.—Case VII (*a*). Congenital dislocation of hip-joint before operation.

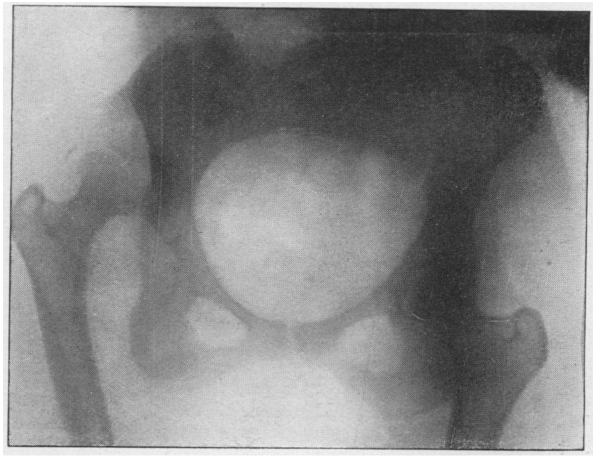


Fig. 9.—Case VII (*a*). After operation.

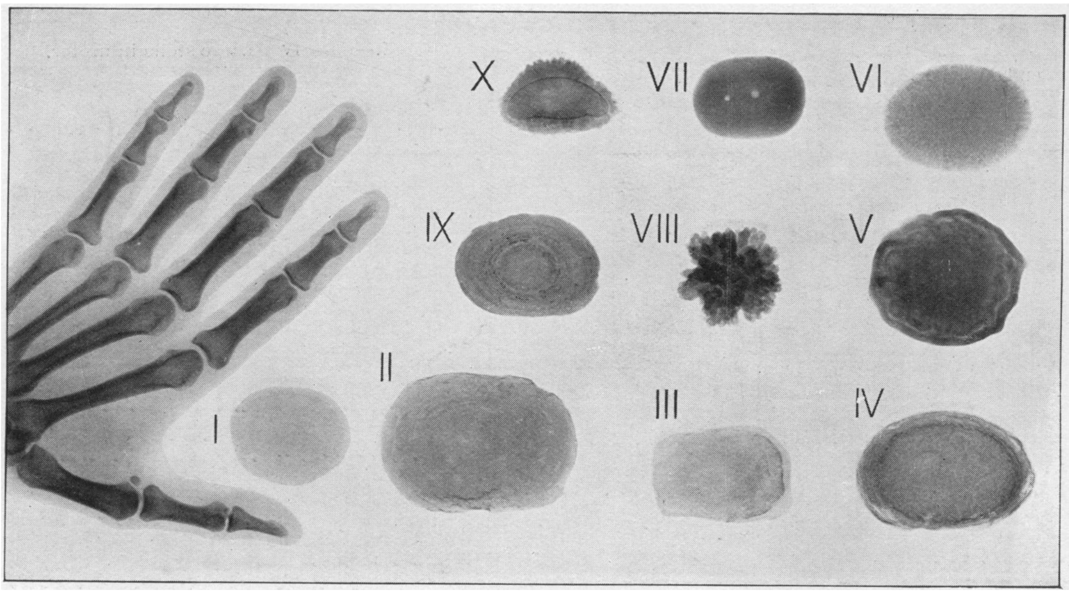


Fig. 10.—Relative opacity of calculi.

I. Uric acid.
II. Uric acid.
III. Biliary calculus.
IV. Uric acid surrounded by impure urate of ammonia.
V. Oxalate of lime and urate of ammonia.
VI. Cystic oxide.
VII. Phosphate of lime.
VIII. Mulberry calculus.
IX. Urate of ammonia and phosphate and carbonate of lime.
X. Cystine and a layer of oxalate of lime.

TO ILLUSTRATE MR. J. MACKENZIE DAVIDSON'S PAPER.