

Middle Articles

Reception of Röntgen's Discovery in Britain and U.S.A.

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Seventy-five years ago, on the afternoon of 8 November 1895, Conrad Wilhelm Röntgen (1845-1923; Fig. 1) discovered what he called "X-rays." The story of the discovery has often and well been told (Glasser, 1933; Underwood, 1945). Within its limits this paper needs only a short summary.

Throughout the nineteenth century experiments with electric charges through rarified gas tubes were conducted by many physicists, among them Michael Faraday, Johann W. Hittorf, Julius Plücker assisted by his excellent glass-blower Heinrich Geissler, William Crookes, Cromwell Fleetwood Farley, Herbert Jackson, Heinrich Hertz, and last but not least Philipp Lenard. The discovery of cathode rays is usually ascribed to Plücker (1858). In 1894 Lenard, encouraged by his teacher Hertz, inserted thin metal windows into discharge

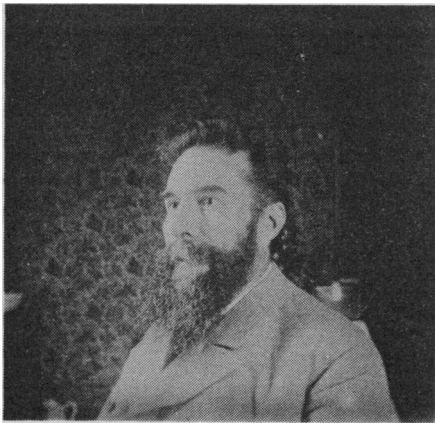


FIG. 1.—One of a stereopair of photographs of Röntgen taken by himself. (By kind permission of the director of the Science Museum, London. Crown copyright.)

tubes and observed that "rays" escaped from and caused fluorescence outside the tube to a distance of not more than 2 cm. Lenard was not the first who while working with cathode rays had observed strange phenomena *outside* gas tubes. According to Sarton (1937), Crookes had photographic plates fogged in his laboratory but had only lodged a strong complaint to their manufacturers. A Philadelphia physicist, A. W. Goodspeed, had accidentally produced an x -ray photograph in 1890 but had discarded it "as a freak" (Glasser, 1933).

Röntgen's historical hunch was that Lenard's penetrating rays were *not* cathode rays. He hermetically sealed a thick-walled Hittorf tube with a black cardboard cover, connected the tube with a large Ruhmkorff induction coil, and drew the curtains. The chance which, to quote Pasteur's famous dictum, "favours only the prepared mind" was the position of a small platinum-cyanide screen lying about one metre from the tube; it lit up when Röntgen passed the current through the tube.

The known failure of cathode rays to penetrate thick-walled tubes, the absence of a "Lenard window," and the dis-

tance of the screen from the tube suggested to Röntgen that the fluorescent effect was due to rays *sui generis*, the specific properties of which he worked out in the amazingly short time of six weeks. No significant advance was made in the knowledge and understanding of these properties until Friedrich, Knipping, and von Laue (1912) established the wave nature and wave lengths of Röntgen rays.

A New Type of Rays

Soon after Christmas 1895 Röntgen submitted the result of his labours to the secretary of the Würzburg Physical-Medical Society with the somewhat unusual request to publish his preliminary communication, "Ueber eine Neue Art von Strahlen" (A New Type of Rays), in the Society's transaction before reading it at a meeting. The editor of the *Transactions* complied with commendable alacrity and Röntgen was able to send out his reprints on New Year's Day 1896 (Röntgen, 1895). It is relevant to this story that the copies sent to the professor of physics in Vienna, Franz Exner, and to the German-born physicist at Owens College in Manchester, Arthur Schuster, contained specimens of x -ray photographs.

The only reference to the potential importance of his discovery to medicine in Röntgen's papers of 1895 and 1896 was this: "If the hand is held between the discharge apparatus and the screen, one sees darker shadows of the bones against the less dark shadows of the whole hand." He could not foresee, of course, that his speculations—"It is possible that the geometrical arrangements of molecules in various bodies influence the penetration of X-rays"—would many years later become the basis of molecular biology and of the genetic code, as little as he could anticipate that x -rays as an experimental tool would lead to Hiroshima.

Accounts in the Press

Unlike some other fundamental scientific discoveries the news from Würzburg reached the world after, and not before, its publication in a scientific journal, though by somewhat unorthodox ways. The photographs sent with Röntgen's paper to Exner in Vienna were produced at a dinner party at Exner's home during the first week of January 1896. Among the guests was E. Lecher, a physicist from Prague. Lecher's father happened to be the editor of *Die Presse*, Vienna's leading daily paper, and Lecher senior knew a hot story when he saw it. On Sunday, 5 January 1896 *Die Presse* carried the news of Röntgen's discovery on its front page (Fig. 2). Röntgen's name was misspelt as "Routgen." *Die Presse's* scientific correspondent, obviously a writer of a pleasantly romantic and prophetic disposition, wrote of "rings freely

"On the first of January I mailed the reprints and then hell broke loose" (from a letter by Röntgen to Zehnder). "... it was the hand that did it" (*The Electrician*, 1896).

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floating around the finger bones." He discounted any chance that this was "only a fairy tale or crude April joke" and ended by stating: "... if we let our phantasies run freely ... we can imagine that one day these rays will be so perfect that only one layer of the body's soft tissues will be transparent to them, whereas deeper layers will be shown on photographic plates. This could be of immeasurable help for the diagnosis of countless diseases other than those of bones. We

Jones could hardly have returned from Germany if indeed he went there at that time (Thurstan Holland, 1937; Cochrane Shanks, 1950).

It is less well known that also on the same evening (7 January) Röntgen's photographs were shown to the members of the Manchester Literary and Philosophical Society by a Dr. C. E. Lees on behalf of the Langworthy Professor of Physics at Owens College, Arthur Schuster (Schuster, 1962). Except for Lord Kelvin, who happened to be indisposed at that time, Schuster was the only recipient of one of Röntgen's reprints.*

Beobachtung und Unterscheidung:
1. Die Röntgenstrahlen sind durchdringend, durchdringen alle Stoffe, durchdringen auch die menschliche Haut, durchdringen auch die menschlichen Knochen.
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Die Presse.

№. 5. Wien, Sonntag den 5. Jänner 1896.

Eine sensationelle Entdeckung.

In den gelehrten Fachkreisen Wiens macht gegenwärtig die Mitteilung von einer Entdeckung, welche Professor Röntgen in Würzburg gemacht haben soll, große Sensation. Wenn sich diese bewährt, wenn die hiermit bezüglichen Mitteilungen sich als begründet erweisen, so hat man es mit einem in seiner Art epochemachenden Geschehnisse der ersten Zeitrechnung zu thun, das fähig ist auf physikalischen wie auf medizinischen Gebiete ganz merkwürdige Konsequenzen bringen dürfte. Wir haben hierüber folgende Notizen: Eine Crookes'sche Röhre — eine sehr hart ausgepumpte Glasröhre, durch die ein Inductionstrom geht — und photographirt mit Hilfe der Strahlen, welche diese Röhre nach außen hin ausstrahlt, auf gewöhnlichen photographischen Platten. Diese Strahlen man, von deren Wirkung man bisher keine Ahnung hatte, sind für das Auge vollständig unsichtbar; sie durchdringen, im Gegensatz zu gewöhnlichen Lichtstrahlen, Goldfolie, organische Stoffe und dergleichen un durchdringliche Stoffe. Metall- und Steinplatten hingegen lassen die Strahlen auf. Man kann bei hellem Tageslicht mit geschlossener Casette

genau feine wie über die einer Skulptur in mit der die auf waren in fertigen; Scheitl Scheitl liegende so wäre later an gewonne larit a

Fig. 2.—First report on Röntgen's discovery. Die Presse, Vienna, 5 January, 1896.

admit that all this is at present only daring speculation . . . but if anyone at the beginning of this century had said that his grandchildren with the help of an electrical apparatus would converse across the oceans he would have been considered ripe for a lunatic asylum."

The story was taken up by Germany's foremost paper Die Frankfurter Zeitung under the headline "A Sensational Discovery." A few days later a copy of the Frankfurter reached a Mrs. Wimpfheimer, a German lady who assisted Robert Jones at his Free Sunday Morning Clinic in Nelson Street, Liverpool. After translating the "sensational discovery" into English she showed it to Jones and to his colleague C. Thurstan Holland, who was to become one of England's pioneers of radiology. There are two conflicting versions of the reception of Röntgen's discovery in Liverpool: Thurstan Holland's (1937): "I regret to say that we both laughed at it . . ." and Frederick Watson's (1934): "Robert Jones crossed at once to the continent and on his return set up a plant at Nelson Street." However, whatever justified claims Liverpool may have to priority and fame in medicine and other fields, the setting up of England's first x-ray plant is not among them.

The news of the new rays had broken in the Daily Chronicle of 6 January 1896, and in the Standard of 7 January (Fig. 3). Once again both papers misspelt Röntgen's name as "Routgen." The Daily Chronicle left its readers in no doubt that "the new conduct of light . . . already in its present stage will be an excellent expedient for surgeons." The Standard assured its readers "that there is no joke or humbug in this matter. It is a serious discovery by a serious German professor." The Standard's Vienna correspondent described the photographs of human hands as "ghastly enough in appearances but from a scientific point of view they open up a wide field for speculation."

Both papers printed only a sketchy and somewhat inaccurate account of Röntgen's apparatus and methods but it is on record that on the evening of 7 January 1896 a brilliant electrical engineer, A. A. Campbell Swinton, after having read the Standard, showed the ghastly pictures of his hand to his friends, a truly phenomenal achievement. By that time Robert

REMARKABLE SCIENTIFIC DISCOVERY.

(FROM OUR CORRESPONDENT.)

VIENNA, SUNDAY NIGHT.

A sensational discovery, which, if the reports are confirmed, is likely to be attended by important consequences for physical and medical science, is spoken of in scientific circles here. A new conductor of light has been discovered by Professor Röntgen, the well-known physicist at the Würzburg University. So far his experiments have resulted in the discovery that light penetrates wood and the flesh of men and animals, without, however, penetrating bones and metals. The professor succeeded in photographing metal weights placed in a shut-up wooden case. The photograph sent to Vienna shows only the weights, but nothing of the case. Another photograph of a man's hand shows only the bones, while the flesh remains invisible. Professor Röntgen's experiments are conducted in the following way.—He takes a so-called Crooke's pipe—viz., a well pumped

out glass pipe, with an induction current going through it, and by means of the rays which that pipe is emitting he photographs on ordinary photograph plates. In contrast with the ordinary rays of light those rays penetrate wooden and organic matter and other opaque substances, just in the same way as the ordinary rays of light penetrate glass. Experiments were also made in photographing hidden metals with the apparatus shut, and produced equal success. The rays penetrated not only the wooden case containing the metals, but also the cover placed before the plate of the apparatus. The scientific world here is much agitated by the discovery, which it is believed will be of far-reaching importance for many branches of knowledge. Already in its present stage it will be an excellent expedient for surgeons, particularly in cases of complicated fractures of limbs, in searching for the bullets of the wounded, &c. The photo will show not only an exact picture of a fracture, or the situation of a bullet, but spare the patient much painful manual probing with the sound.

Fig. 3.—First report in Britain. Daily Chronicle, 6 January, 1896.

The first report on Röntgen's discovery in a British scientific journal was a short note in The Electrician of 10 January, 1896. The writer, who optimistically believed "that the whole phenomenon seems likely to admit of ready explanation," ended with the somewhat unfair remark: "there are few persons who would care to sit for a portrait for two hours which would only show the bones and rings of the fingers." This comment is characteristic for many others in the early days of x rays, the practical application of which were thought to be mainly in "photography."

Comment in British Medical Press

In the British medical press the Lancet's annotators were the first to comment on the new rays. On 11 January (Lancet, 1896a) the two main "annotations" were headed "A Clouded Sky" and the "Searchlight of Photography" respectively. The first dealt with Dr. Jameson's raid into the Transvaal and ended on the familiar note that "the hopes of a diminished income-tax will be dissipated by all these war alarms." The second, in a more cheerful mood and written by someone who knew his Dickens, quoted Samuel Weller addressing Serjeant Buzfuz: "If they was a pair o' patent double million magnifyin' glass microscopes of hextra power, p'raps I might be able to see through a flight o' stairs and a deal door." "If we are to believe an announcement from Vienna" the annotator cautiously added, Sam Weller's pipe dream might have become true, but he did not pretend to say "in how many ways such a discovery might, if it be true, be turned to the highest account." One week later (Lancet, 1896b) the annotator by now familiar with Swinton's pictures had become slightly less cautious: "With confirmatory evidence like this before us from an independent investigator the possibility of

* In those momentous days of 1895-1896 the wives of physicists seem to have had a thin time. According to Röntgen's wife her husband slept and ate in his laboratory, was morose, abstracted, and "resented the intrusions of mundane matters." Young Mrs. Schuster was kept waiting in a cab outside Owens College on a cold winter night while her husband read Röntgen's "extraordinary communication" in his warm laboratory (Schuster, 1962).

the application of this discovery as an aid in medical and surgical practice is a shade nearer probability." In the same issue the *Lancet's* (1896c) Berlin correspondent reported on "the general opinion that the new discovery will produce quite a revolution in the present methods of examining the interior of the human body."

On the same day the *British Medical Journal*, which seems to have missed the deadline the previous week, published a letter from Professor Arthur Schuster. He was convinced "that a most important discovery had been made . . . with many possible medical applications." He also suggested—what at that time could have been only a highly inspired guess—that "Röntgen's rays are vibrations of extremely short lengths" (Schuster, 1896).

On 25 January 1896 both the *Lancet* (1896d) and the *British Medical Journal* (1896a) produced x-ray photographs of human hands, the *Lancet* scoring again by adding that of the lower half of a frog. On 1 February 1896 the *British Medical Journal* (1896b) weighed in heavily with a three-column leading article, "The New Photography," giving a fairly accurate account of Röntgen's experimental methods and apparatus and adding somewhat condescendingly, "the application of the discovery to the photography of hidden structures is a feat sensational enough and likely to stimulate even the uneducated imagination." It did indeed. A few weeks later English entrepreneurs advertised "X-ray proof underclothing—especially made for the sensitive woman" (*Electrical World*, 1896).

More significant was the leader writer's remark: "Curiously enough glass is exceedingly opaque" a phenomenon which had also puzzled the *Lancet's* annotators. None of them seems to have known of the lead content of certain commercial glass or they had missed Röntgen's statement that "lead, 1.5 mm. thick was practically opaque." The *British Medical Journal's* leader writer solved the problem by stating, "we are in command of certain peculiar rays which have a standard of opacity of their own, the medical interest of which lies in the fact that bone is opaque and flesh very transparent to them."[†]

In the meantime *Nature*, which on 16 January 1896 had given Röntgen's discovery only 17 lines (*Nature*, 1896), had published an accurate translation of Röntgen's paper on 23 January, with comments by A. A. C. Swinton (1896) which included an excellent photograph of a "living human hand." The photograph had been made with an exposure of 20 minutes "from a Crookes tube being held vertically upside down . . . about two inches above the centre of the hand." Swinton, however, stated that since then he had been able to reduce the required exposure to four minutes.

In the British medical press Robert Jones and Oliver Lodge (1896) published the first report on the practical use of x rays in surgery under the title "The Discovery of a Bullet Lost in the Wrist by Means of the Roentgen Rays." The patient, described as "a lad aged 12 years" was comfortably seated at a table, "and rather more than two hours' exposure was given." The lost pellet was clearly outlined at the base of the third metacarpal bone.

By that time (22 February) traumatic, osteomyelitic, and tuberculous bone lesions had been shown on radiographs at the Salpêtrière and Trousseau Hospitals in Paris (*British Medical Journal*, 1896b). In the United States, E. B. Frost had photographed a broken ulna on 3 February (Frost, 1896).

One day after Frost's excellent photograph had appeared in *Science* the editor of the *Journal of the American Medical Association* was still very sceptical: ". . . it is suggestive of

practical medical and surgical possibilities. It is only a hint however and whether it is ever to be realised to any extent is perhaps open to serious question."

Further Publications

The further developments in 1896 and the trials, tribulations, and triumphs of the early radiologists have never been better described than by Thurstan Holland (1937). By the end of 1896 he had collected 261 plates, and their list contained inter alia rheumatoid arthritis, strumous dactylitis, rickets, fetuses, coins in the oesophagus, fishes, and mummy birds. He had also attempted "to examine chests and even the abdomen."

The British Medical Association commissioned Sidney Rowland to investigate the clinical uses of x rays at the beginning of February 1896 (*British Medical Journal*, 1896c). They could have hardly chosen a better man if only for the fact that by the end of February he was able to produce x rays of hands with exposures of 20 seconds as against Swinton's 4 minutes (*British Medical Journal*, 1896d). In May 1896 Rowland published the first journal exclusively concerned with radiology, the *Archives of Clinical Skiagraphy*, the predecessor of the *Archives of the Röntgen Ray* (1897-1915), and later continued as the *Archives of Radiology and Electrotherapy* (1915-23).

Perhaps the most outstanding medical pioneer in the new field was John McIntyre, of Glasgow, who had published 18 papers on radiology by the end of 1896. By demonstrating a kidney stone as early as July 1896, he had left the field of traumatic and orthopaedic surgery to which *The Electrician* in January had relegated the new radiations by saying: "So long as individuals of the human race continue to professionally inject bullets into one another, it is well to be provided with easy means for inspecting the position of the injected lead, and to that extent aiding the skilled operators whose business and joy it is to extract it."

In September 1896 the British Association for the Advancement of Science met in Liverpool under its President, Sir Joseph Lister. Shortly before delivering his Presidential oration Lister visited Thurstan Holland's "x-ray department" and had his hand photographed. He opened his address on "The Interdependence of Science and the Healing Art" with an account of Röntgen's rays and pronounced the all too prophetic words: "If the skin is long exposed to their action it becomes very much irritated, affected with a sort of aggravating sunburning. This suggests the idea that the transmission of Rays through the human body may not be altogether a matter of indifference to internal organs, but may, by long continued action, produce injurious irritation or salutary stimulation" (Lister, 1896).[‡]

The index to volume 53 of *Nature* (1896) lists no fewer than 163 articles, letters, and notes on x rays from many countries. According to Glasser (1933) not less than 1,044 books and pamphlets on Röntgen's rays were published throughout the world in 1896. The first monograph in Britain was H. S. Ward's (1896) *Practical Radiography*, and it is perhaps characteristic for the unfamiliarity of human anatomy in the light of x rays that its frontispiece showed a human heart "in situ," upside down (Fig. 4).

It is difficult to think of any event the news of which spread throughout the scientific world with equal speed. Between January 1896 and the day of the first heart transplant in 1967 there certainly was no discovery or feat in the field of medicine which, as the *British Medical Journal*

[†] Seventy-five years later the Medical Protection Society Ltd. (1970) found it necessary to draw the attention of their members to the litigation hazards of "undetected glass" by saying "in fact almost all glass in common use is sufficiently radio-opaque to give a shadow when in soft tissues. Radio-opacity depends upon the mass absorption coefficient of the constituents and density of the particular glass."

[‡] Lister's oration, a classic of its kind, encouraged an anxious mother to ask an attendant at an x-ray stall at a London Exhibition to see "whether her little son had really swallowed a threepenny bit." She had read "that a great doctor, Sir something Blister, had seen a halfpenny in a boy's 'sar-cophagus'" (Hunter, 1896).



FIG. 4.—Frontispiece of H. S. Ward's (1896) *Practical Radiography*. (Kindly supplied by the Chester Beatty Research Institute Library)

chose to call it, "stimulated the uneducated imagination" to a similar extent.

The librarians of the British Museum, the Brompton Hospital, the Nuffield Library, *Nature*, the British Association, the North Staffordshire Medical Institute, the Chester Beatty Research Institute, and the Oesterreichische Nationalbibliothek very kindly provided me with much of the basic material for this paper. I also thank Miss R. J. Posner, Dr. L. A. Bowcock, and Mrs. M. Hampton for their help. Drs. Cameron and Hill, of Messrs. Pilkington, kindly enlightened me with regard to the radio-opacity of commercial glass.

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MEDICAL EDUCATION

Origin and Employment of the Medical Graduates of the University of Aberdeen 1931-69

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Summary: A survey was made of the medical graduates of the University of Aberdeen, 1931-69. The recent increase of graduates of non-British origin, the continuing high intake of women and their subsequent attrition, and the high rate of emigration, have combined to reduce substantially the number of these graduates working in Britain.

Introduction

There is little published information on the medical graduates of individual universities, apart from a series of papers by Whitfield (1962, 1964, 1969b) describing the medical graduates of the University of Birmingham. We report the findings of a survey of the origin and employment of the medical graduates of the University of Aberdeen of 1931 to 1969.

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 ‡ Housewife, Aberdeen.

Present Survey

Sources of Information

The names and normal residences of the graduates were obtained from Aberdeen *University Calendars* of 1931-69. The type and place of subsequent medical employment were traced from the past and current *British Medical Directory*, *Canadian Medical Directory*, the *Medical Register*, the Aberdeen *University Roll of Graduates, 1925-55*, and the Aberdeen *University Review*.

Findings

Proportion of Men and Women Graduates.—Out of the 2,766 graduates of the whole period 1931-69, 659 (23.8%) were women. The proportion of women graduates increased from 7.8% in 1931-5 to 29.3% in 1946-50. Since then the proportion has remained relatively constant. During 1951-65 26.0% of the graduates were women; the proportion of women graduates of the academic years 1960-7 (27.1%) is similar to that