The Newsletter of the Radiology History & Heritage Charitable Trust

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Editor: Dr Adrian Thomas
Department of Diagnostic Imaging
Bromley Hospital
17 Cromwell Avenue, Bromley Kent BR2 9AJ
Tel: +44(0) 181 289 7070
Fax: +44(0) 181 289 7003
E-mail: Adrian.Thomas@btinternet.com

Editorial Notes

This newsletter contains two pieces by Uwe Busch from the Röntgen Museum in Germany. The first is an article on Radiology in 1896 and the second is the text of the talk that he gave to the RHHCT at the British Institute of Radiology on the 26th October earlier this year. The talk encompassed the history of the Deutches Röntgen Museum, the life of Wilhelm Röntgen and the uses that the X-rays have been put to in the 100 years following the discovery. X-rays have had many uses other than medical and it was interesting to hear about X-ray crystallography and X-ray astronomy. The illustrations were excellent and it is a shame that they cannot be reproduced. I am delighted that we are able to reproduce both pieces in this newsletter.

Uwe Busch generously presented the RHHCT with copies of letters sent by British scientists to Professor Röntgen and it is hoped to show these letters at Radiology 99.

The September 1998 issue (no: 205) of the Radiological Protection Bulletin (NRPB, Chilton, Didcot Oxon. OX11 ORQ) is devoted to Marie Curie and the Radium story. There is an excellent article by Alan Jennings on the evolution of quantities in radioactivity. Also to be recommended is the article by dick mould in the December British Journal of Radiology.

At the recent meeting of the committee of the RHHCT concern was expressed about obituaries in Clinical Radiology, Clinical Oncology and the British Journal of Radiology. Obituaries are a source of historical reference material and are invaluable. We are concerned about the discontinuation of obituaries. Obituaries are a valuable source of information and it is much to be regretted that our journals will no longer have them.

The RHHCT is affiliated to the British society for the history of medicine and we have a brief report in the 1998 News.

The RHHCT now has a web site. The address is:

www.biosys.net/rhhct
Please let me have any comments about the functioning and the content of the site.
I hope you enjoy this newsletter. If you have any material for the next issue, which should come out for Radiology 1999, then please sent it to me.
Seasons greetings and best wishes for 1999.

Adrian Thomas

The Progress in Radiology in 1896

U. Busch

German Roentgen Museum, Remscheid-Lennep

Regarding the history of radiology, the year 1896 plays an outstanding role in the discoveries and inventions in radiodiagnostics and the first signs of radiotherapy. In the first year after the discovery of X-rays, a total of 49 books, brochures and 1044 scientific essays were written on the scientific aspects and possible applications of the newly discovered rays (1). A multitude of these publications dealt specifically with the possibilities of application in medicine.

On 8th November 1895, while doing research work on the electric discharge procedure in diluted gas which at that time was very popular in form of cathode ray research in every laboratory research, Wilhelm Conrad Roentgen (1845-1923) a „new kind of rays“ which had been unknown to the other physicists so far. It took Roentgen only six weeks to finish his first scientific work on this research. On Saturday, 28th December he submitted his manuscript to the secretary of the Physical-Medical Society in Wuerzburg. On Tuesday, 31st December he received the off-prints which he sent together with nine X-rays and New Year greetings to his colleagues by mail. Within the area of Wuerzburg, Roentgen submitted his announcements personally. It was his friend, Professor Franz Exner (1849-1926), the director of the II. Physical-Chemical Institution of the university in Vienna who was one of his very first addressees. Exner and Roentgen had been acquainted since their academic days in Zurich. Both had been assistants to Professor August Kundt. On the occasion of a discussion evening on Saturday, 4th January 1986, Exner showed the X-rays which had been taken by Roentgen to his assistants. One of the present people, Ernst Lecher, at that time Professor of physics at the German University in Prague and thereafter in Vienna, informed his father, who was then the editor of Vienna’s daily newspaper „The Press“ on the performance of Exner that very evening. And in the same night, the first article was written on X-rays and published in „The Press“ on Sunday, 5th January, under the headline „A Sensational Discovery“. Apart from the physical facts the possible development of these new rays was described in a prophetic manner.

The news spread with the speed of lightening. Shortly afterwards an article was published in the „Frankfurter Zeitung“ (7.1.), in „the Electrical Engineer“, New York (8.1), in the „Wuerzburger Anzeiger“ (9.1), in „The Electrician“, London (10.1), in „Lancet“ and „British Medical Journal“ (11.1), in „Le Matin“, Paris (13.1), in „Nature“, London and in „Times“, New York (16.1), in „Science“, New York (24.1.) and in „La Settimana“, Florence (25.1.). Due to the world-wide telegraphic communication of the sensational news, Roentgen received already an inquiry from the American physician Robert Watkins from New York as early as on 8th January requesting him to send some radiographs.

In addition to Watkins, the other physicians in Germany mostly heard about Roentgen's discovery through the newspapers. Surprise, laughter and speechlessness frequently culminated in the utterance „we must have such an apparatus".

The fascination of this sense of a new era in medical diagnostics was impressively described by the orthopaedic surgeon, Hermann Gocht (1869-1938). In order to get more information about the new rays, Gocht and his friend Gustav Opitz contacted the glass blower, Carl Heinrich Florenz Mueller in Hamburg (1845-1912). „When I think of this first evening! ... The factory rooms of Mueller were on the raised ground floor of the front building; the mercury air pump for the evacuation of the tubes stood in the front room and was operated by Mueller's factotum, Mr. Schmidt, a kind, very capable but simple man, who became a victim of the X-rays, too.

Furthermore there were some smaller inductors and a big 25-30 cm inductor with a platinum interrupter; more than a dozen X-ray tubes were available. Mueller had already produced some plates with bowls, spirals, drawing instruments, fingers and parts of hands. At first he showed us his installation and explained the construction and evacuation of the tubes. In a back room sat a glass blower, Mr. Becker, who created new tubes and parts of tubes in front of our very eyes. These first tubes were still constructed in a way that the cathode rays started from a more or less big aluminium plane mirror and fell on the opposite convex glass wall. This spot of the glass wall fluoresced especially intensively and the birth place of the X-rays always became so very hot that one had to be very careful with the current supply; sometimes after a long exposure time, the tube suddenly burst with a big bang.

A small apparatus was also part of this very simply range of instruments. This small apparatus had been built by Mueller himself who gave it the name "Searcher": A black cardboard cylinder which was closed at one end; some bariumtetracyanoplatinate crystals had been fixed on the inner bottom of the cylinder.

„In my thoughts I can still see and hear the joy with which Mueller demonstrated everything to us, and I remember the tension and impatience in anticipation of the first experiments. Finally. the inductor was connected and the pear-shaped blown tubes lit up for the first time. Opposite of the cathode, the glass wall fluoresced especially intensively; when the current had been switched off he made us feel the hot tube wall and finally we put the searcher before our eyes in order to catch a glimpse of the cathode rays and to observe the lightning of the bariumtetracyanoplatinate crystals. At first we saw nothing until suddenly a weak light appeared. This evening, the small searcher wandered from one eye to another with us three, the light was very slight but to us it meant an almost supernatural radiance and a glance into a new world" (3).

First Medical Successes

The early understanding of the possibilities in the application of the new rays in medicine developed from the amicable relationship between Roentgen and Exner. As early as on 10th January, the brother of Franz Exner, the physiologist Sigmund Exner, reported on Roentgen's discovery to the Imperial-Royal Society of Physicians. After his speech, Sigmund Exner addressed Professor von Neusser, the director of the II. Medical University Hospital, and asked him to send convenient patients for the purpose of testing the diagnostic application of X-rays at his brother's physical institute. It was the assistant of Neusser, Gustav Kaiser (1871-1947) who was entrusted with this task. The first medically indicated radiograph was taken together with Eduard Haschek (1875-1947) who at that time was the assistant of Franz Exner at the physical institute. The patient's hand showed the traumatic change of the middle phalanx of the 5th ray.

In addition to this radiograph, Sigmund Exner presented a second one on 17th January which was important for the history of radiology. The anatomist Tandler in Vienna placed the hand of a corpse at the disposal of the assistants Eduard Haschek and Otto Lindenthal (1872-1947) at the physical institute. The arterial vessels were filled in with the Teichmann's solution (iodine solution), a mixture of chalk, cinnabar and paraffin. After an exposure time of 57 minutes, the first angiocardiogram was created.

On 23rd January, Roentgen received an invitation to hold a lecture to the Physical-Medical Society in Wuerzburg. „Mister Roentgen, being welcomed by long-standing vivid applause holds his lecture on 'A new kind of rays'. Towards the end of his speech, the silhouette of the skeleton of a human hand was taken by radiograph, it was the right hand of the honorary president of the society, Prof. von Koelliker. The latter thanks the lecturer on behalf of the society for the report the importance of which is unique to the annals of the meetings and brings a cheer for Roentgen joined in enthusiastically by the members and the entire auditorium in the densely occupied lecture hall of the physical institute. The suggestion of Prof. von Koelliker to call the new 'X-rays' Roentgen-rays' invoked a new common wave of cheers.

In the following discussion which was opened by the 1. Chairman, Prof. von Koelliker and Roentgen talk about the possibility of making the new rays applicable for medical purposes ...“

Nevertheless, in addition to a lot of fantastic visions which were uttered in the discussion, several surgeons warned of an overestimation of the possible applications in medicine. The doubts pertaining to the medical application of X-rays was impressively contradicted by the surgeon from Vienna, Dr. Albert von Mosetig-Moorhof (1838-1907). On 24th January, Mosetig-Moorhof presented a radiograph of a gunshot injury and a radiograph of the foot of a twenty year-old female patient with a hammer toe to the medical society in Vienna during a meeting. The radiograph distinctively showed which of the two toes belonged to the metatarsus joint. The necessary operations were performed according to the radiological results. During this meeting, Mosetig-Moorhof emphasised that the X-rays are appointed to be applied in surgical practice, too, and that they were by no means 'a toy' (5)".

Apparatus and technical proceedings

Due to the quick spreading of the news about these sensational rays and the fascination about the first X-rays of hands, research work began to fan out widely on an international level. The improvement of the technical apparatus for the production of X-rays belonged to the first great successes. Above all, the ionic tubes had to be improved. In his second notification, Roentgen explains the construction of special Roentgen tubes.

'... According to my experience gained to date, platinum is best suited for the production of most intensive X-rays. For some weeks now I have been using a discharging device with good success in which a concave mirror of aluminium serves as a cathode, and a platinum sheet is placed against the mirror axis at an angle of 45° and installed in the bending radius to function as an anode ... (6).

An own Roentgen industry developed rather quickly. Production workshops like that of C.H.F. Mueller in Hamburg or Emil Gundelach in Gehlberg had produced special X-ray tubes since spring. As soon as the discovery of Roentgen had become known, the engineer Werner Siemens (1816-1892) and the mechanic Johann Georg Halske (1814-1890) founded a telegraph construction institution in 1847 and they immediately started producing their own X-ray devices. In March, the company Siemens & Halske applied for their first patent for a special X-ray tube which already contained an appliance for the regulation of the vacuum (7).

Special consideration was dedicated to the development of the photographic radiographic technique, and several publications were released on this topic. In this manner, C. Henry from Paris suggested the application of phosphorescent white vitriol for the magnification of the effect of the X-rays (8). However, since X-ray absorption increases immensely with the ordinal numbers of the chemical elements in the luminophore, the American X-ray pioneer, Michael Pupin (1858-1935), achieved considerably better results with fluorescent screens made from calcium tungstate in early February. His X-ray of a hand with a shot gun wound is very impressive (9).

Shortening the rather long exposure time was a great technical challenge. In May, and with the assistance of preparatory work performed by John MacIntire (1857 – 1928) (10) while taking an X-ray of a hand and forearm, Hermann Gocht (1869-1938) succeeded for the first time in reducing the exposure time step-by-step from 45 to 5 seconds with an especially developed X-ray apparatus and the support of C.H.F. Mueller (1845-1912) who had constructed an X-ray tube which was exactly adjusted to the other equipment (11). Gocht's vision of possible snapshots was roughly realised by the development of the apparatus for X-ray cinematography by the Scotsman John MacIntire in December. The movements of frog's legs could be seen in a first X-ray film which was shown to the Philosophical Society in Glasgow (12).

The method of the production of stereo pictures in photography had been known even before the discovery of the X-rays. Roentgen himself as an enthusiastic photographer had made a lot of stereo pictures. On 11th March 1896, Elihu Thomson reported on the production of stereoscopic X-rays (13). In the same month, A. Imbert (1850-1922) and H. Bertin-Sans (1862-1952) showed impressive stereograms of two mice to the Academy of Science in Paris (14).

It was the special radiographic photo plates which were produced for Roentgen by Carl Moritz Schleussner (1868-1952) which contributed to a noticeable improvement of the photographs. The radiographic plate which was coated with a special silver bromide emulsion made a drastic reduction of the exposure time possible and thus cut the radiation exposition time from some minutes to a few seconds.

Under consideration of these broad technical improvements, various impulses for the successful application of X-rays in the different classical fields were discussed during the year 1896.

Skeletal radiography

Due to technical conditions at the beginning of 1896, the application of X-rays had to be limited to the description of the bone structure in the range of the extremities. Initially, it was possible to achieve great successes in the search for foreign bodies. On 19th January, the physician L. Pfaundler in Graz described the location of a needle in the hand of a 12 year-old girl (15). Before the X-ray was taken, the surgeon had tried to locate the foreign body in the wound. The following surgical extraction was performed without any problems after having taken a radiograph.

In quick sequence, further successes in the localisation of foreign bodies under application of X-rays were published. After having made several technical improvements especially to the X-ray tubes, Professor Eulenburg was able to take very good X-rays of bullets in the brain in Berlin in August (16).

Apart from initial success in the localisation of foreign bodies, examinations in the area of the illustration of fractures suggested itself. At the end of January, Fessler succeeded in producing the first X-ray of a forearm with an exposure time of 12 minutes at the physical institute of the university in Munich (17).

In addition to the localisation of foreign matter and fracture diagnostics, the punctual analysis of bone diseases were of great importance for surgical purposes, too. First attempts to show a sarcoma on a shin-bone were made by the surgeon Professor Franz Koenig (1832-1910) in Berlin. Part of the joint of the tibia of a 46 year-old woman was distinctively swollen. The diagnosis confirmed beyond any doubt the fact of a neoplasm. Taking X-rays in vivo failed. It was only after amputating that hey succeeded in taking the first X-rays of a tibia sarcoma (18).

On 17th February, Huber presented to the Society for Inner Medicine in Berlin various X-rays which he had taken at the Technische Reichsanstalt, some of which were examples of acute joint damages (19).

The quick technological progress allowed the enlargement of the spectrum of diagnostic possibilities. In June, Charles Thurston Holland (1863-1941) had already presented X-rays of congenital deformations of hands (20) when Julius Wolff (1869-1933) succeeded in the radiological diagnostics of a congenital hip joint luxation and managed to prove the subsequent surgical treatment by radiographs. ‘Now, pertaining to the Buka hip joint radiograph, I became convinced that with radioscopy we have a trustworthy means to answer a lot of important questions especially in view of the treatment of the congenital hip joint luxation being vividly discussed in surgery. Furthermore, my conviction was supported by viewing the X-rays of a congenital hip-joint dislocation before and after a bloody and bloodless reposition performed by me...'' (21)

Ludwig Zehnder (1854-1949), Professor of physics at the University of Freiburg and student of Roentgen in Giessen, succeeded for the first time in April to describe the entire human skeleton in a radiograph. The first composed whole body X-ray measures 1.84 m and was taken from a dead soldier in 9 sections. The exposure time was 5 minutes per section. The arms were taken from an other soldier who had a missile lodged in his hand and a deformation on the other hand. To hold his head still for a whole hour was the task of the photographer Kempke himself.

Thus, in the course of the year 1986 numerous anatomic changes as well as diseases of the skeleton could be recognised by means of radiographs and with the increasing level of knowledge it was possible to treat these more successfully.

Thorax

In March, the British pioneer John MacIntire succeeded in taking an X-ray of a thorax organ in situ for the first time. The radiogram enabled him to examine the form and the size of the heart (22). One month later, Francis Henry Williams (1852-1936) published the first chest X-rays taken at the Massachusetts Institute of Technology in Boston (23).

However, for these X-rays one had to accept an exposure time of 60 minutes due to the weak performance of the X-ray unit which resulted in rather blurry radiographs. The diagnosis was accordingly very limited and was based on details such as form and size of the heart, position of the diaphragm, large shadows caused by pleural fluid, translucence by pneumothorax, broadening of the mediastinum and the description of the thorax skeleton (24).

Application of Contrast Media

In his first publication Roentgen described the different capacity of absorption. ‘... Similar to metals even salts in liquid or steady form can be sorted out according to their permeability ...’ (25). In March, Wolf Becher (1862-1910) a physician from Berlin took knowledge of this result of research and worked on the description of inner organs through the application of contrast media. ‘the characteristic of solvents to prevent the X-ray from passing through are grounds for taking X-rays of inner hollow organs in the animal body by means of Roentgen’s method. It is only required to introduce the solvent of a metallic salt into the hollow organ in such a quantity that the walls of it are somewhat tightened. I performed some experiments like that with white mice and guinea pigs ... An X-ray of a human stomach in vivo according to Roentgen provides the selection of a solvent which must have two characteristics: in order to avoid any damage one must be able to introduce it into the human stomach: but at the same time it must be permeable to Roentgen’s rays ...’ (26).

For the selection of convenient contrast media, different substances had been examined for their application. Becher used lead acetate in his examinations. Haschek and Lindenthal used mercuric sulphide for the description of the blood vessels of an amputated hand (compare picture 3). Dutto used calcium sulphate (27) for the demonstration of blood vessels, and Ernst Sehrwald (1861-1945) performed in-vitro examinations on the capability of absorption of halogens in July and thus he provided the way for the application of non-metallic elements like iodine compounds as a contrast medium (28).

Gastro-intestinal, Urological and Gynaecological Radiology

After Becher had described initial approaches towards depicting the stomach of a guinea pig (see above), J. C. Hemmeter made his patient swallow a balloon with an attached tube which was then filled with lead acetate. After the radiograph was taken the lead acetate was aspirated and both the bag and tube removed from the stomach (29). Due to the lack of a convenient, i.e. non-toxic contrast media, Carl Wegele suggested a practicable solution for the radiological description of the stomach of a living person in April. For the description of the greater curvature, a soft stomach tube should be orally introduced like a gastric tube and thereafter a metallic spiral be added. ... ‘ When one introduces a thin metal wire into the lumen of such a positioned stomach tube, it should make the metallic filling on the plate visible by means of X-rays. A 10-pence piece put on the navel with a plaster could serve as a guide ... Until recently, the thickness of the cross section of the body and the required length of the exposure time were a hindrance for the performance of our idea, that is what we learned from an authoritative side ...’ (30). Half a year later, E. Lindemann returned to this idea and succeeded in producing the first X-ray in-vivo of the greater curvature. In his experiments, Lindemann used a rubber tube as a stomach tube which contained a fine copper mesh. (31).

Urologists were highly interested in the application of X-rays. In July 1896 John MacIntire already undertook to describe a kidney stone radiologically. After the first success with a kidney preparation, he was able to make a diagnosis of a kidney stone in his patient because the structure and the silhouette of the organ with the kidney stone were clearly visible on the X-ray. The subsequent operation confirmed this diagnosis (32).

First research in radiological diagnostics of gynaecology was performed by the American obstetrician, Professor Edward Parker Davis (1856-1973) in March. For the first experiment, he put the head of a newly-born child into the pelvis of a female corpus. After an exposure time of one and a half hours he received the first gynaecological radiograph.

After this first success, Davis dared taking an X-ray of a female patient. It took him one and a half hours until he was able to recognise the body of the foetus. But he did not succeed in the description of the head. ‘... While the experiment failed to distinctly outline the skeleton of the foetus, it offers information which may be of value in further attempts ...’ (33). It was in March, too, that Adolphe Pinned (1844-1934) from the Academie de Medicine in Paris demonstrated the results of the research in the radiological description of a foetus within an uterus preparation received by Henri Varnier (1859-192) and James Chappuis.

Dental Medicine

After Roentgen’s discovery, even dentists very quickly recognised the diagnostic advantage for their own special medical field. Especially in dental surgery, significant progress was achieved through the new possibilities of a radiological examination. This development was introduced by the attempts of the dentist Otto Walkhoff (1860-1934). In the middle of January, Walkhoff asked the physicist, Professor Giesel in Braunschweig, to take an X-ray of his back teeth. Small pieces were cut from the commercial plates and subsequently again wrapped light-proof. Walkhoff received the first intraoral X-ray after an exposure time of some 25 minutes. In addition to the torture of the long exposure time one also had to accept other inconveniences such as the loss of hair, for instance.

Some time later, the physicist, Professor Walter Koenig (1859-1936) also published the radiograph of front teeth in upper and lower jaw along with 14 photographs with X-rays. Koenig emphasises that '... the X-rays of the teeth are not only able to prove the position and the form of the fillings in the teeth but we are also able to examine parts of the teeth which are sticking into the jaw bones ...' (36).

Veterinary Medicine

Animals were often used for the first radiographic experiments. In the photographic portfolio gathered by Joseph Maria Eder (1855-1945) and Valenta, one can find numerous radiographs of animals. In the enclosed brochure, the authors emphasise the special usability of these pictures for zoologists (37).

Despite the great interest of veterinarians in the new diagnostic possibilities provided by X-rays, their application only developed gradually. In addition to the high technical requirements, the initially long exposure time prevented the practicable application of radiographs in veterinary medicine. In contrast to human medicine, radiology developed only slowly in veterinary medicine.

The scientific interest, however, was evident at a very early stage. In 1896, five treatises were published. The authors were Eberlein and Troester in Germany, Hobday and Johnson in England and Lemeoine in France.

After the advantages of the radiodiagnostic procedure on animal preparations had been demonstrated by Professor Richard Eberlein (1869-1921), the Director of the Royal Veterinarian University in Berlin (38), it was Hobday and Johnson who succeeded in taking X-rays of a living horse in September (39).

Radiobiology, Radiotherapy and Radiation Injuries

Three weeks after the Scottish X-ray pioneer, Campbell Swinton (1863-1930) had been unable to demonstrate any negative biological effects in spite of intensive and continuous research with X-rays, John Daniel, a physicist at the Vanderbilt University in Nashville, who was able to report on a new phenomenon which had not been mentioned so far on 23rd April. Following request by a physician, the physicist was asked to localise a bullet in the head of a child by means of X-rays. However, even after an exposure time of one hour, no radiological result was achieved. Three weeks later the child lost its hair (40). In April, the physician Wilhelm Marcus from Berlin reported one case of dermatological skin changes with a 17 year-old young man who had repeatedly put himself up for disposal with radioscopic experiments. 'On the side of the face which was exposed to the tube and which was the first part to be exposed to the rays, we can notice a diffuse redness almost changing to a brown hue which covers the whole side of the face ... On some parts of this reddened skin one can see clear laminations ... If one touches the reddened skin with slight pressure, the skin itself becomes pale but without loosing the hue totally. All qualities of sensitivity prove to be normal. There was no itching at all. The young man became aware of the changes on the side of his face while occasionally glancing into the mirror just a fortnight after the start of the experiment. The next day he tried to restore his normal image by washing his face with vinegar, but his only success, according to his own information, was that his skin loosened and hung down in large shreds ...' (41). Due to this report, several physicians used X-rays for the therapeutic treatment of hypertrochoses, eczema and mycoses. The dermatologist Leopold Freud in Vienna (1868-1943) at the institute in Eder was the first one to perform the first basic scientific research towards analysing the biological efficiency of X-rays for the treatment of diseases in November. His object was a small girl who was disfigured by a big mole which looked like an animal's hide on her neck and back. This impairment was so serious that her parents asked that her hair be removed. Within a period of 10 days the child was being irradiated two hours every day.

However, a short time later, serious skin injuries arose such as reddening, swellings and blisters. During further progress, a big ulcer with central necrosis developed.

This short description of the history of the application of X-rays in 1896 cannot and does not claim to be complete. Instead, it was our general aim to use some select examples to illustrate the broad range of scientific questions involved here.

Author: Uwe Busch
Scientific Collaborator and Deputy Director
German Roentgen-Museum
Schwelmer Str. 41
D-42897 Remscheid
Germany
Tel. ++49-2191-62759
Fax. ++49-2191-163145
E-mail. UWBUSCH@AOL.COM

Pictures:

1. Publication on X-rays, published in: 'The Press' on 5th January 1896
2. First medically indicated X-ray
3. First angiogram of a hand
4. Geheimer Rat Prof. Dr. Albert Rudolf von Koelliker (1817-1905)
5. Professor Koelliker's hand, taken in Wuerzburg on 23rd January 1896
6. X-ray of a hammer toe.
7. One of the first X-ray units industrially made in Germany by Siemens & Halske.
8. First X-ray by intensifying screen showing a hand with a gunshot wound.
9. Part of the first cineradiography showing the movements of frog legs.
10. Stereogram of two mice.
11. X-ray of a needle in a girl's hand.
12. X-ray of a bullet in the brain.
13. X-ray of a fracture of the radius.
14. X-ray of a tibia sarcoma.
15. Preparation cut.
16. Gout in the finger joints.
17. Congenital deformation of a hand.
18. Congenital hip-joint luxation.
19. First whole body X-ray.
20. First X-ray in situ of the heart.
21. First X-ray of the thorax.
22. Angiocardiography of a guinea pig's stomach.

23. Absorptometry of halogens in vitro.
24. Illustration of the great curvature using a gastric tube.
25. X-ray of the head of a new-born child in a pelvic preparation.
26. Uterine specimen with a 3-and-a-half months-old foetus (left) and sagittal section (right).
27. First dental X-rays.
28. Two salt-water fish.
29. Ankle joint of a pony in vivo.
30. Freund's therapy case before and after radiotherapy.

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Deutches Röntgen Museum – Today and in the Future.
Uwe Busch
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NR	LINKS	RECHTS
1	*{Title of the lecture}* Ladies and Gentleman, Dear Colleagues, Dear friends. It is a great honour for me to be invited to present a paper at the British Institute of Radiology. Before I begin with my lecture, I would like to thank very much Miss Marion Frank for her perfect arrangements. My wife and I are very appreciated to have the opportunity to enjoy your	*{WCR: Portrait with his sign}* hospitality, Marion. Ladies and Gentleman, in my lecture I would like to inform you about the German Roentgen Museum and our special activities. Please allow me to ad to the announced title of my talk some historical aspects about the development of our museum.
2	*{Text: History of Museum}*: First plans to establish a Roentgenmuseum were made by the German Roentgen Society (DRG). At the 1st. April 1907 the DRG decided in their inaugural session of the III. German Roentgen Congress to build up a Roentgen-museum. A museums committee was founded and was represented by: Eberlein, Walter, Grashey and Cowl. The president of DRG, Albers-Schoenberg, pointed out that the special tasks of this museum are to represent the development of radiology in general just as the development of the DRG. The members of DRG began to collect important X-ray machines, tubes, radiographs, instruments, protection equipment, slides, ...	*{Arno Breker: Genius of the Light}* The draughty realisation of this museum was unfortunately prevented by the economic crises. In 1920 the museums-committee was still looking for suitable rooms. Parallel to this project the past president of the DRG, Paul Krause, suggested in 1929 to build up a Roentgen memorial at Roentgens birthplace in Lennep. At 30. Nov.1930 the memorial "The Genius of the light", sculptured by the German sculptor Arno Breker was solemn unveiled by Paul Krause and the Lord Mayor of Remscheid, Dr. Hartmann.
3	*{Inauguration of the museum 18. 6.1932}* During the ceremony Krause suggested to establish a museum in the house where Roentgen was born with a special focus on Roentgens biography. Dr. Hartmann was enthusiastic about this idea. Unfortunately there was no	*{Prof. Krause in entrance of the new museum}* chance at that time to buy this. To go on with the plans the town council decided to buy an old townhouse from 1803. Here, the first section of the museum was opened at 18. June 1932. As first director of this museum Dr. Rees was elected .
4	*{View of the museum from the memorial}* The development of the museum was supported even in bad economic times by the town council of Remscheid.	*{The museum in the historical town of Lennep}* In 1937 a new exhibition hall was opened to the public. You can see historical outside views of the museum.

5	*{Text: Roentgenianum}* Independent from this events in Lennep the DRG founded a Roentgen-Office in Munich in 1937. The special tasks of this office were to elaborate a plan for a Roentgenianum, a place for radiological research and education with a special scientific library, a radiological archive and a collection of X-ray machines and related devices.	*{Architecture model of the Roentgenianum}* The realisation of this project, that was planed for the year 1940, became unfortunately a victim of World War II. Furthermore the collection was destroyed in 1944 by bombs. This attack destroyed likewise the engagement of the DRG to establish a museum for radiological science and education.
6	*{Second enlargement of the museum: Document }* Besides this, the progress in Lennep went on. The museum survived wartime without worth mentioning damages. The museum's collection grew because of numerous donations. In 1951 the "Society of Friends and Supporters of the German Roentgen Museum in Remscheid- Lennep, Incorporated was founded.	*{Building in the foundation stone19.3.1955}* In co-operation with the X-ray industry the second enlargement could be realised in 1955. The ceremony of building in the foundation stone was realised by the German Minister of the Interior, Dr. Gerhard Schröder and the president of the Society of friends and supporters, Dr. Seifert, a famous German manufacturer of X.-ray equipment.
7	*{View of the new building}* It was the task of the second Director of the museum Mr. Ernst Streller, to fill the empty rooms with life.	*{Ernst Streller}* Without any professional staff it was hard for Mr Ernst Streller not to fell in resignation.
8	*{View from inside with the new exhibition}* It took 4 years of intensive work to reorganise the museums exhibition.	*{Inside view}* Ernst Streller fulfilled this great task. You can see some insight views of the new organised exhibition in 1959.
9	*{Ceremony at city hall}* The inauguration of the new exhibition took place at 20. July 1959 with a celebration in the City Hall in Remscheid.	*{Outside view of the museum with flags}* All participants of the 9. International Congress of Radiology (ICR), that took place the same time in Munich, were invited to come to Remscheid. The streets of Lennep were decorated with a lot of different national flags to welcome the international guests..
10	*{Inauguration of the new exhibition 20.7.1959. }* Numerous guests were attending the inauguration in Lennep. The Lord Mayor Dr. Frey was able to welcome as honorary guest the American ambassador Dr. James Bryant Conant. By the way, Dr. Conant was Chief scientific advisor of the American Uranium Project at Berkley Radiation Laboratory. This wartime mobilisation of science project was established in 1939 by the American president Roosewelt after being alarmed by Albert Einstein about	*{Party-time in the museum}* Nazi activities to get heavy water and uranium. All the visitors were enthusiastic about the new exhibition.
11	*{Acquisition of the House of Roentgen}* Roentgen's birthplace situated in a distance of 150 meters from the museum, was acquired by the town in 1964. After restoration and reconstructing it became part of the museum in 1980. It is now used as a study centre.	*{ Memorial tablet }* The museums library and the museums guest rooms are housed here. Since 1987 it also contains the comprehensive library of the DRG. You can see the memorial tablet mounted outside this house in 1920 to celebrate Röntgen's 75 birthday.

12	*{Ground plan of the museum by 1995}* In 1995 the museum got a huge donation from the European photo-industry. The past president of our Society of Friends and Supporters, Prof. Peter E. Peters, the director of the department of clinical radiological at the University of Münster, was working very hard to mobilise more sponsors. With all this support the third enlargement of the museum could be realised.	*{Outside view of the Museum with new Café}* It was a very big casualty for the museum that Prof. Peters died in 1997. The new entrance area with a café and a museum's shop was opened to the public in 1996. Today the museum comprises an exhibition area of 2500m^2. Unfortunately only 15% of our collection can actually be shown to the public. Due to lack of space and a breathtaking development in all fields many topics can only be touched on.
13	*{WCR Biography text }* Ladies and Gentleman, it is the special privilege of the museum to preserve the estate of Wilhelm Conrad Röntgen. So please allow me to give you a short introduction in his biography. Wilhelm Conrad was **born in Lennep at 27.3.1845**. He was the only child of Friedrich Conrad Röntgen, a distinguished cloth manufacturer and his wife Charlotte Con-stance, nee Frohwein, a native from Amsterdam. The family was well known in Lennep. In 1848 many	*{WCR portrait time in Giessen }* European countries, including Germany, were shattered by revolution. Röntgen's parents sold their house at Gänsemarkt and emigrated at **27. March 1848** to **Apeldoorn (NL)**, the place were the family of Röntgen's mother lived. In addition the economic prospects were much better in The Nether-lands. Wilhelm Conrad attended primary school there, and later a private boarding school. He spoke fluently Dutch and felt very much at home in this Dutch town. In **1862** his father sent young Wilhelm to **Utrecht** to visit the technical school.
no ch 13	Röntgen got good **report** from technical school - apart from his mark in physics - but he did not get a school examine. Somewhat curious happened which was to have a considerable impact of his future live. What would be a harmless students prank by today's standards caused a "consilium abeundi" - he was expelled from school. What actually happened has never been completely clarified. According to Otto Glassers biography, one of Röntgens classmates had drawn a **caricature** of a teacher on the firescreen. Röntgen was standing in front of this picture when the teacher unexpectedly arrived. He thought Röntgen was the culprit. In 1865 he was sent to Zurich to visit the Polytechnic School. In 1868 he passed the examine and received his **Diploma** in Mechanical engineering. He continued his studies and in 1869 he obtained his Ph. D. from the University of Zürich following submission of his **thesis** entitled **"Studies on gases".** It was then in Zurich where he met his later mentor **August Kundt**, a very important and famous German experimental physicist. He became his assistant in 1871. Both worked very successfully together. In 1872 he **married** Anna Bertha Ludwig. Together with Kundt Röntgen went in 1872 to Strasbourg where he finally became assistant professor of physics and was appointed lecturer. In 1875 he went to Hohenheim but left after	one year to became associate Professor at the institute of Kundt in Strasbourg. In **1879** he was offered the **Chair of Physics at Giessen University**. It was in Giessen Röntgen performed very important physical research that made him famous in the physical world long before he discovered X-rays. In **1888** Röntgen received an offer from the **University of Würzburg** he could not decline. WCR's scientific accomplishments had made him so outstanding, that he was offered Friedrich Kohlrausch's post as full Professor of Physics and Director of the new Physical Institute of the **University** of Würzburg, when Kohlrausch went to Strasbourg**.**. WCR's accurate experimental methods of investigation made him an ideal successor of the master of technique of physical measurement. In **1894** Röntgen received the ultimate academic accolade by being elected "**Rector**" (President of the University of Würzburg). On a special request of the Bavarian government Röntgen accepted in 1900 the Chair for Physics at the University of **Munich**. Wilhelm and Anna Bertha Röntgen went to Munich and they stayed there until their death. When his beloved wife died in 1919, Röntgen became very lonely. He retired from his chair in physics in 1920 but continued to serve as Curator of the Physico-Metronomical Institute of the Munich Academy of Science. On **10.2.1923 he died** in Munich from intestinal carcinoma. His mortal remains were put to rest beside those of his wife and his parents in the **old cemetery** in Giessen.
14	*{Genealogy}* The museum collected information about Röntgen's Genealogy. Roentgen's family tree was compiled by the	*{David Röntgen}* One of Röntgen's ancestors from a side line, David Röntgen (1743-1807), became very famous almost a hundred years

	German naval captain Paul Windgassen and is been preserved in the museums archive. Until today we have good contacts to the family line that emigrated to the United States.	before his birth as a cabinetmaker. He made beautiful inlaid woodwork which was sold to collectors and to Royalty, including Catherine of Russia, Queen Marie Antoinette of France and Frederick William the second of Prussia.
15	*{WCR as young man }* One of the main museum's effort is to represent Röntgen as a man. Young Wilhelm was expected to follow his father's footsteps. There is nothing in his youth which pointed out his future genius. He had great love for nature and was found of roaming through forests and fields with his friends. He had a special aptitude for making all sorts of mechanical contrivances.	*{Drawing of his suction pump}* When he was first permitted to smoke cigars, he received a beautiful meerschaum holder from his uncle, and constructed a little suction pump with which he quickly and automatically seasoned it. Röntgen was always a loyal and faithful friend to his colleges. Modesty was one of the characteristics which persisted throughout his life.
16	*{WCR the man: WCR with his parents}* The museum owns a lot of documents and pictures showing Röntgen and his family. I like to show you now some examples. On left you can see a picture showing young Röntgen and his parents during their time in Apeldoorn.	*{WCR the man: Pupil in Apeldoorn}* On right side you can see a portrait of Röntgen as pupil during his time in Utrecht.
17	*{WCR the man: Report from technical school Utrecht }* Röntgen's report from technical school in Utrecht attested him a very bad performance in physics.	*{WCR the man: Diploma}* Röntgen received his diploma in mechanical engineering from polytechnic school in Zurich in 1869
18	*{WCR the man: Country house in Weilheim}* In 1889 Röntgen bought a country house and a hunting ground in Weilheim, close to Stuttgart. Hunting was a pleasure and a recreation for Röntgen. Although his colour-blindness made it difficult for him to distinguish the red deer from a green background, he was a very good hunter and shot.	*{WCR the man: At the terrace of his house}* During the woodcock season he got up at 3.30 in the morning. He enjoyed nature and especially the morning atmosphere and the activities of the birds so much that he often forgot to fire his gun. You can see him standing at the terrace of his house, relaxing from his work in Munich and listening to the voices of nature.
19	*{WCR the man: Hunting in Weilheim }* He often spend his weekends together with his friends hunting. Pictures from 1898 showing him with his friends and his huntsman Lenz in his hunting-ground in Weilheim	*{WCR the man: Hunting in Weilheim}* Failures in hunting often made Röntgen very angry, disagreeable and moody for the whole day.
20	*{WCR the man: Pontresina: Riding a coach }* Almost 40 years ago Röntgen and his wife spent their holidays in Pontresina, Switzerland. Röntgen got very good remembrance to his study time in Zurich where he often spend the weekends hiking in the mountains. The Röntgen's usually spent their vacations with congenial colleges, among whom were the zoologist Boveri and his	*{WCR the man: Engadin mountains in Pontresina}* wife and daughter, the surgeon Krönlein, Dr. Ritzmann, Prof. von Hippel, Prof. Lüders, Prof. Hitzig and Prof. Schönborn. During vacations all the metropolitan entertainment's, such as dance, concerts, etc. were taboo. You can see on left side both in a coach in front of their hotel in Pontresina and Röntgen holding an alpine flower in his hand.

21	*{WCR the man: Röntgen-photographs}* Röntgen was very interested in photography. It was his great hobby to make a lot of photographs during his holidays. Some examples you can see here. The museum owns a huge collection of real Röntgen photographs.	*{WCR the man: Röntgen-photographs}* I like show some of the beautiful pictures from landscapes he took during his holidays in Switzerland and Italy. On left side: the Hotel Sand in Pontresina in1896 On the right: a beautiful view of the Engadin mountains
22	*{WCR the man: Röntgen-photographs}* In spring their favourite place was Cadenabbia in Italy. The Röntgen's always stayed in same rooms at the expensive hotel Bellevue. Furthermore they had a key to the beautiful "Villa Carlotta" through the courtesy of the Prince of Meiningen. The pictures were was taken in 1897. **A nice anecdote**: Röntgen, who groomed himself carefully and always looked faultlessly dressed in a tuxedo, appeared one evening at a fine dinner in Bellevue hotel with one patent leather shoe and one nailed mountain shoe, and of course this news spread very quickly over Cadenabbia and for a long time furnished excellent material for jokes.	*{WCR the man: Röntgen-photographs}* On his next birthday he received a wonderful little figure of a man which was made out of dried plums dressed in a tuxedo and with one patent leather shoe and one mountain shoe on its feed. The gift was accompanied by the following letter: "The British Colony of Cadenabbia, very much flattered to see that you have adopted their national evening dress, has decided to have your statue sculptured by the celebrated sculptor, Professor M. Klinger in Leipzig, in order to perpetuate the memory of your first appearance in this dress. We have the pleasure of sending you a miniature model of the statue in honour of the sixty-second anniversary of your birthday and wish you many happy returns of the day. Yours respectfully, The Very Reverend of Sheepshead."
23	*{WCR the man: Röntgen-photographs}* In wintertime 1898 the Röntgen' s visited Davos, Switzerland. Röntgen mad a picture of a glacier and	*{WCR the man: Röntgen-photographs}* together with friends they went skating at a frozen lake.
24	*{WCR the scientist: Röntgen as rector}* The scientist Wilhelm Conrad Röntgen got great reputations as an excellent experimental physicist. You can see him here in the official gown of a rector of the University of Würzburg. In his address given on the occasion of becoming rector he said: "Nature often allows amazing miracles to be produced which originate from the most ordinary observations and which are, however, recognised only by those who are equipped with sagacity and research acumen, and who consult experience, the teacher of everything." Röntgen's scientific work embraced:	*{WCR the scientist: Thext}* **15 scientific papers in Strasbourg (1870-1879)** incl. "On the Electrodynamic Rotation of the Plane of Polarisation in Gases" (later called the Kerr-Effect) **18 publications in Giessen (1880-88)** incl. "On Sounds produced by Intermittent Irradiation of a Gas" and "On the Electromotoric Force produced by moving a Dielectric in a homogeneous Electric Field (Proof of Maxwell's Theory of Electrodynamic) **18 papers in Würzburg (1889-1898)** incl. "On a new kind of rays" and 2 other papers on X-rays **7 papers in Munich (1904-1921*)*** incl. "Pyro- and Piezo-electrical Investigations" Please allow me to introduce you with two important papers.
25	*{WCR the scientist: Devices Photoacoustic effect}* The first one was published in 1881 and titled „On sounds produced by intermittent irradiation of Gases“ Intermitted radiation from a light source, that produced head radiation can be absorbed by an illumination gas	*{WCR the scientist: Text Photoacoustic effect* meter with a microphone tones can clearly be heard. The light absorption is dependant on the kind of the illumination gas and on the wavelength of the light. The method is nowadays used for the spectroscopy of non-radiant transitions. In easier words:

	filled in a glass tube With a manometer rising and falling of the pressure of the gas can be measured, an effect A. G. Bell demonstrated in solids. If substituting the mano-	We are able to analyse the swinging and dancing of stimulated gas molecules. It's now put to use in environment protection to proof air pollution.
26	*{WCR the scientist: Dielectric shift current}* „On the electromotoric force produced by moving a dielectric in a homogenous electric field" was published in 1885. In 1873 the genius Scottish physicist J.C. Maxwell developed the first unify theory in physics. He was able to describe electricity and magnetism in one theory. His Electrodynamics contents a system of four differential equations. Because of mathematical symmetrical reasons he put in one equation a physical quantity - a special	*{WCR the scientist: Text: Dielectric shift current}* kind of a current - never measured before. The physical world was confused about this fact and the Prussian Academy of Science asked a prize question to measure the predicted current. Röntgen, using a special designed condenser with a rotation dielectric, was able to proof, that the movement of an electric polarised dielectric had the magnetic effect of a current; that was called dielectric shift current. The measuring of this quantity brought the desired breakthrough of Maxwell's theory.
27	*{WCR the scientist: X-rays}* At 8.11.1895 he discovered X-rays in his laboratory in Würzburg. He used a very simple equipment to analyse discharge phenomena's in deluded gases. In an interview	*{WCR the scientist: X-rays* with the reporter H. Damm from McClure's magazine he answered the question "What did you think?" with the famous words "**I did not think; I investigated**".
28	*{WCR the scientist: Radiograph of Bertha}* On 22. December Röntgen asked his wife **Anna Bertha** to make a **radiograph of her hand**. On the photographic plate the bones of her hand and two rings can be seen distinctively The picture became a historic document and the 22.12.1895 is the true birthday of radiology and radiography as a medical speciality.	*{WCR the scientist: Manuscript}* On the 28. December 1895 Röntgen submitted his short **manuscript** „On a new kind of rays - preliminary communication" to the secretary of the Würzburg Physico-Medical-Society. Three days later Röntgen obtained reprints of his manuscript and had sent them, together with nine illustrating pictures, to his scientific colleagues as a New Year's Greeting. Within ten days of the submission of the manuscript the news had spread to the entire world.
29	*{WCR the scientist: Lecture at the Berlin palace }* On January 11. Röntgen received a telegraph from the adjutant of the **German Emperor** with an invitation to present his discovery at the emperors palace in Berlin. On January 13, Röntgen demonstrated some experiments in a **private lecture in Berlin palace** before the German Emperor Wilhelm II and the royal family.	*{WCR the scientist: Radiograph of Bertha}* On 23.1.1896, Röntgen presented his work at the special **conference of the Würzburg Physico-Medical Society.** In front of the audience Röntgen made the radiograph of the hand of the famous German anatomist Prof. **Albrecht von Koelliker**. The exposure time was about 30 minutes. The audience gave him standing ovations after the presentation and von Kölliker recommended to call the new rays henceforth as "Röntgen rays". This expression became very popular in German speaking countries.
30	*{WCR the scientist: Honours}* During his lifetime Röntgen got a lot of Honours. At 10. 12.1901 Röntgen was awarded the first **Nobel Prize** in Physics. He travelled to **Stockholm** but refused to give	*{WCR the scientist: Nobel prize}* an official Nobel lecture. Röntgen bequeathed the Nobel prize-money of 50.000 Kroners to the University of Würzburg to support young scientists.

31	*{Tasks of the museum: The Röntgen-Plaque}* Another very important task of the museum is to organise the annual awarding ceremony of the Röntgen-Plaque. This high esteemed scientific award was endowed by the town of Remscheid in 1951. The Röntgen-Plaque is been awarded by the Lord Mayor to persons who made great contributions to progress and common usage of X-rays in science and practice.	*{The Röntgen plaque}* Four Nobel-Prize winners are among the numerous holders of the Plaque from all over the world. Max von Laue, German Physicist William Lawrence Bragg, British Physicist Arthur Holly Compton, US-American Physicist Godfrey Newbold Hounsfield, British Electrical Engineer
32	*{The Röntgen-Plaque: von Laue}* Max von Laue was been awarded the Röntgen-Plaque in 1952 for the evidence of diffraction and interference of X-rays in crystals.	*{The Röntgen-Plaque: Hounsfield}* Godfrey Newbold Hounsfield was been awarded the Röntgen-Plaque in 1980 for his invention of Computer tomography.
33	*{The Museums collection embraced: Text}* 287 Exhibits out of Röntgen's estate 615 X-ray machines and related devices 395 X-ray tubes 1600 Documents 1500 Photographs 12000 Books 120 Different Periodicals	*{The Museums collection: Furniture}* The museum presents some beautiful furniture out of Röntgen's estate in his birthplace. The museum owns his old toilet pot and his washbowl but both are not in use nowadays.
34	*{The Museums collection: Desk and bookcases}* The museum owns the desk and some bookcases from Röntgen's time in Würzburg. The pendulum clock hung already in his laboratory while he discovered X-rays Röntgen owned a very huge library with about 10.000 contemporary scientific books. Unfortunately he decided in his last wish to sell this library and to spent the money in a foundation to support young scientists. In his bookcase you can see the number of books that could be	*{The Museums collection: Cabinet 1905}* preserved. The X-ray cabinet from 1905 is well preserved and demonstrated impressively the dangerous work in the pioneer years of radiology. The tube was used without any shielding and the electrical cables were laid through the room without any isolation. The main instrument was a fluoroscopic screen. The exposure time of a radiograph for instance of a hand was about 5 minutes. The collection of tubes rendered the continuous work without daily regeneration of each tube.
35	*{The Museums collection: Transparent women}* In the entrance of the medical department a life-sized functioning model "The Women of Glass" demonstrated the radiological imaging of inner organs. During the lecture the organs are been lighted up and on TV-screens	*{The Museums collection: control panel}* the actual radiographs are shown to the visitor. The beautiful control panel of an X-ray unit was been manufactured by the German company Koch & Sterzel in Dresden in 1933.
36	*{The Museums collection: CT}* A revolution in radiology was the development of Computer Tomography. When Sir Hounsfield was awarded the Röntgen-Plaque he brought as a gift this beautiful EMI Marc I scanner from Basel, Switzerland.	*{The Museums collection: MRI}* Next step in the progress of radiology was the development of MRI. This 0.2 Tesla MRI Scanner was one of the first scanners build by Siemens in Erlangen.

37	*{The Museums collection: Symmetry instrument}* The Symmetry Instrumentarium was constructed in 1922 by Reiniger, Gebbert & Schall in Erlangen for irradiation. The generator provided 250 kV. To protect the sensitive tube against high voltage irregularities a spark stretch was installed. During an irradiation session often	*{The Museums collection: Hand of Paul Krause}* electrical discharges occurred that made most of the patient very fearful. Professor Paul Krause decided in his last wish, that his hand with radiation damage could be amputated after his death for presentation in our museum. Paul Krause was a victim of the Nazis. He began suicide in 1934.
38	*{The Museums collection: Geißler Tube}* The museums owns a huge collection of all sorts of X-ray tubes. The beautiful "Cathode Ray Tube" on left side was manufactured in 1880 by the German glass blower Florence Müller in Hamburg. When using high voltage the tube begins to shin in different colours.	*{The Museums collection: Hittorf tube}* The kind of a Hittorf tube Röntgen on left side was probably used for Röntgen's discovery. The tube has got a focal spot of some square centimetres. With this tubes first radiological experiments were made early in January 1896. The tube was manufactured likewise by CHF Müller in Hamburg.
39	*{The Museums collection: Goetze tube}* The glass blower Robert Goetze from Leipzig and the physicist Professor W. König from Frankfurt were the first who used a platinum mirror as anticathode in a tube. You can see one of the first focus tubes made in 1896 on left side.	*{The Museums collection: Lilienfeld tube}* The X-ray tube on right side got a cold cathode and was developed by the German physicist Otto Lilienfeld in 1911. The tube represented an intermediate stage between the progress from ionising tubes to high vacuum tubes which were developed by William David Coolidge in 1913 in laboratories of GE in Schenectady, USA.
40	*{The museums collection: Portrait Goodspeed}* The museum owns a glass plate of the first radiograph ever taken by **Arthur Willis Goodspeed** (1860-1943) by accident at the physical institute of the University of Pennsylvania in Philadelphia. Goodspeed and his friend W.N. Jennings were photographing electric sparks and brush discharges on the evening of 22.Feb.1890. After some such experiments had been completed, the table was still littered with loaded photo plate holders and other apparatus when Goodspeed brought out some Crookes tubes and demonstrated them to Jennings.	*{First „shadowgraph" 22.2.1890)}* The next day Jennings reported that when the plates were developed he had found a very curious phenomenon: two round discs superimposed upon the spark tracing on the photographic plate negative. No one could explain this curious effect, and the plate were put aside with other freak photographs and were forgotten. Six years later the plates were re-examined. Another exposure was made with the same apparatus under similar conditions, and the results were the same. Goodspeed concluded a lecture on X-rays on 22. February 1896 with his experiment and said: „We can claim no merit for the discovery, for no discovery was made..."
41	*{The Museums collection: First cinematography}* In March 1896 the Scottish X-ray Pioneer **John MacIntire**, (1857-1923) from the Royal Infirmary in Glasgow was able to make the first cinematography.	*{The Museums collection: MacIntire's letter to Röntgen}* His X-ray movie showed the movement of frog legs. He sent a letter to Röntgen on 11. March 1897 and enclosed a copy of his film.
42	*{The Museums collection: Documents}* One of the first physicists who answered Röntgen was the famous **Lord Kelvin** from UK. He wrote a quick answer on 6.1.1896. Lord Kelvin was ill at the time when he reached Röntgen's letter and was not able to study the reprint in detail. That is the reason why he only wrote a few words. Ten days later he sent another letter.	*{The Museums collection: Documents}* Röntgen received an invitation for a dinner at 19. Sep. 1896 from the **Medical Institution of Liverpool**. Röntgen was invited to meet Sir Joseph Lister Bart and other members of the British Association. Röntgen often refused all these invitations because of the sometimes bad health condition of his wife.

43	*{The Museums collection: British Roentgen Society* Some other interesting examples of our collection of documents from UK are shown here. Röntgen was been invited to attend as a honorary guest the Inauguration Ceremony of the British Roentgen Society on 5. November 1897. Professor Silvanus Thomson sent an invitation card and a program of the ceremony to Röntgen in 1897.	*{The Museums collection: UK, The Electrician}* Ladies and Gentleman, we have got a collection of about 42 documents written from UK to Röntgen in our archive. We made copies of this documents and I have got the great pleasure to submit you these copies for your archive. At the end of my talk I would like to give these copies in the hand of Prof. Isherwood, (Dr. Adrian Thomas).
44	*{The Museums collection: Photography König }* The museums owns likewise a huge collection of radiographs. I would like to present to you some examples. Very early in 1896 Prof. Walter König from the physical institute of University of Frankfurt made experiments with X-rays. He published a book on X-ray photography already in March 1896.	*{The Museums collection: First radiograph of a mummy}* On right side you can see one of the first radiographs taken from an Egyptian mummy from the collection of the Senkenberg Museum in Frankfurt.
45	*{The Museums collection: Modern Radiographs: 3D}* The Röntgen Museum is not an antique museum. We are interested to present modern radiographs as well. Very impressive for our visitors are three-dimensional pictures reconstructed from CT and MRI data with "VOXEL-	*{The Museums collection: 3D}* MAN". These examples are donated to the museum by Professor Karl-Heinz Höhne, the director of the department of mathematics and computer science in medicine at the University of Hamburg.
46	*{The Museums collection: Veterinary}* Beneath the human radiographic collection we have got a huge collection of veterinary radiographs. Two examples you can see. On left side you can see a radiograph of a	*{The Museums collection: veterinary }* horse-shoe and on the right an inflammation of a milk gland of a cow.
47	*{The Museums collection: Non destructive testing}* A very interesting application of X-rays is the non-destructive testing method. The museum owns a radiograph of the American liberty bell and two radiographs of cars in original size.	*{The Museums collection: Mercedes 190SL}* The picture right shows the Mercedes 190SL that was driven by Rosemarie Nitribitt, a very famous and notorious person during the time of the economic miracle in the sixties in Germany. The exposure time of this radiograph was about 50 hours and the costs were double of the costs of the car itself.
48	*{The Museums collection: Comscan}* In 1995 the Röntgen-Plaque was awarded to two young scientists from Philips Hamburg who developed the COMSCAN. This mobile X-ray machine is measuring the deflected Compton radiation coming back from peace of material when been irradiated with an X-ray beam.	*{The Museums collection: Comscan}* It allows to make tomographies like a CT-scanner. For example wings of aircraft's can be analysed in layers. You can see a radiograph of a section in an aircraft wing that shows a broken carbon swinger.
49	*{The Museums collection: Cezanne Paintings}* The museum has got a nice collection of examples	*{The Museums collection: Cezanne painting}* shows a complete other painting underneath: A portrait picture

	using X-rays to analyse art objects. The radiograph of the painting of Paul Cezanne named "La Baie d'Estaque"	of Mrs. Cezanne.
50	*{The Museums collection: Guitar from Padua}* In 1994 the Germanisches Nationalmuseum in Nuremberg made in co-operation with Siemens CT-scans from some of their exhibits.	*{The Museums collection: Symmetry instrument}* You can see a master guitar from Padua, Italy made in the 17. Century. The radiograph unveils the view of the inner structure of the resonance body of this guitar.
51	*{The Museums collection: Authentic check}* With X-rays the scientists are able to analyse the authentic of ancient documents. This printed paper derived from the "Catholicon" from Johannes Balbus de Janua, unfortunately it is undated. A very good method to check the date is to analyse the watermark which was	*{The Museums collection: }* characteristic for the printer. With electron-beam-autoradiography in this example the watermark of Johannes Gutenberg (1397-1962) could be found. With other information the date of printing this paper could be fixed for the year 1460.
52	*{The Museums collection: Physics}* Physical research was very influenced by Röntgen's discovery. The question of the physical nature of X-rays inspired the German Physicist Max von Laue in 1912 to analyse whether a crystal is able to deflect X-rays. Together with his colleges Friedrich Knipping and	*{The Museums collection: }* Walter Friedrich he was able to receive the first X-ray picture (fluoroscopy) of a crystal. Some days later the first X-ray-interference picture of a crystal was made. This was the starting point of crystallography.
53	*{The Museums collection: Crystallography}* The structure of the DNA as a double helix was predicted by the British biochemist Francis H.C. Crick and the American biochemist James D. Watson in 1953. In the same year the British biophysicist Maurice H.F.	*{The Museums collection: 3D-Model DNA}* Wilkins was able to proof this idea. He made the first X-ray-structure-analysis of genetic material that you can see on left side. With modern computers the three-dimensional structure of the DNA can be generated on the basis of this radiograph.
54	*{The Museums collection: Crystallography}* Nowadays synchrotron radiation is been used for macromolecular crystallography. These problems are aimed at understanding the living cell and this will undoubtedly lead to important medical and social developments of benefit to all. The museum has got very good connections to the European Synchrotron Radiation Facility (ESRF) in Geneva. One example is shown here. Haemoglobin, a protein found in red blood cells, transports oxygen from the lungs to the tissues whilst myoglobin, a protein found in muscles, stores the oxygen for conversion into energy as required. When Sir John Kendrew determined the structure of myoglobin in 1960, it immediately posed a problem: there was no obvious way for the oxygen to get in an out of the molecule. Where are theses channels which let the oxygen in and out? How quick does the protein structure respond to ligand binding and dissociation? To address this problem	*{The Museums collection: }* K. Moffet from University of Chicago made experiments of triggering the dissociation of carbon monoxide from a monoxy myoglobin crystal (MbCO) with a 10 nsec pulse and measured the Laue diffraction patterns with 150 psec polychromatic X-ray pulses. CO was used as a surrogate for O_2 because it is easier to photo-detach from Mb and rebinds to the protein more slowly. You can see the Laue pattern from MbCO recorded in a single pulse of 150 picoseconds with a CCD camera and an image intensifier. The pattern contains 2000 reflections at 1.8 Angstroem resolution. With a computer the ground state of MbCO protein is shown in two ways: on left, helixes are representing by ribbons, the heme is shown in red and the CO is green and black. On the right the atoms are represented by their the Van der Waals radii. You can see that the CO is hidden in the protein interior. The ability of the CO to exit the heme pocket illustrated that protein structure is not static but dynamic with channels opening and closing.

55	*{The Museums collection: X-rays at everyday life}* Besides all scientific claims the museum is very interested just so to collect trivial exhibits depending X-rays. On left side you can see an illustration of an X-ray examination in children's book written by a very famous German author of children's books "Janosch". He wrote: "Next examination: Fluoroscopy. 'What is Fluoroscopy' asked the little bear. 'X-Ray' said Dr. Walter-frog, the radiologist. 'What is X-ray?' asked the little bear. X-ray is, when the little tiger goes into this box and is been illuminated with light. The light is been shined through him and in front of him I am standing. I can see through the little tiger and I can see what's wrong with him. - Ah stripe slipped."	*{The Museums collection: Ma with X-ray eyes}* X-rays entered Hollywood in 1963. With an enormous and new trick-technique the movie "The Man with X-ray Eyes" was produced with the famous actor Ray Milland. You can see a poster of the movie.
56	*{Projects: Mummies }* Next I like to inform you briefly about some interesting museum's projects. In 1994 we presented the special exhibition "Computer and Mummy". At the example of an 2500 years old ancient Egyptian mummy from the Kestner Museum in Hannover, modern analysing methods in ancient mummy	*{Project: Mummies}* research should be presented. The mummy was put into a CT-scanner and 256 layer were made of the mummies head. With VOXEL MAN the data was converted into three-dimensional views.
57	*{Projects: Mummies }* The CT-data was sent to a special milling-machine and the skull of the mummy was formed from a	*{Projects: Mummies}* polypropylene block. Subsequent the face of the mummy was reconstructed by an pathologist.
58	*{Projects: Women in Radiology}* With our special exhibition "Women in Radiology" we tried to show the historic and actual situation of women in radiology and radiography.	*{Projects: Women in Radiology}* We had the great pleasure to present our exhibition this year at RAD 98 in Birmingham.
59	*{Projects: The Invisible Sky}* In close co-operation with the German Max-Planck-Institute of Extraterrestrial Physics (MPE) we organised a special exhibition about "The Invisible Sky". This exhibition depended on the data of the X-Ray-Satellite ROSAT, a project of MPE (GER), NASA (USA) and University of Leicester, (UK) Left, you can see the beautiful constellation of the Orion taken with an optic telescope. Right you can see the computer arrangement of the constellation of the Orion	*{Projects: The Invisible Sky }* area taken with an X-ray telescope. There are some interesting aspect. First there are quite more stars to be seen, that means: A lot of stars emit X-rays. The moon that dominated the optic picture is only poor in the X-ray picture. The Sirius A dominated the optic picture but the Sirius B dominated the X-ray picture (double-star-system). Especially the phenomenon's at the birth and the - sometimes - sudden death of stars, Supernovae, Neutron Stars and Black Holes are of interest for X-ray astronomy.

60	*{Projects: The Invisible Sky}* ROSAT was able to measure more than 80.000 new stars in universe. You can see on left side the All Sky Survey.	*{Projects: The Invisible Sky}* In 1999 the next generation of X-ray satellites will be launched. You can see on left side the XMM (X-ray Multi-Mirror-Mision) of the European Space Agency (ESA).
61	*{Projects: The Invisible Sky}* Inside view of our exhibition presented between April and September in our museum.	*{Projects: The Invisible Sky}* We are going to present this mobile exhibition hopefully at the ECR meeting in 2000 in Vienna.
62	*{Projects: Radiology in developing Countries}* We are intending to arrange a special mobile exhibition on the subject "Radiology in Developing Countries" We are very interested to become information about: Past and present of radiology in different countries Pictures about past and present daily practise	*{Projects: The Invisible Sky}* Pictures about technical equipment Stories and anecdotes about pioneers Specific national difficulties Education in radiology and radiography Special requests about the future.
63	*{Röntgen Museum: The Future}* Since ten years the museum is hard working to get the next enlargement. Some preliminary plans were figured out in 1991. Because of the economic crises the plans could not be realised until now. In co-operation with the regional government we are trying to find a way for this project. Unfortunately the times in Germany for support technical and nature science museums are very bad. There is a small chance to succeed with the idea to establish an education centre for industrial X-ray companies. You can see some architecture ideas for an enlargement.	*{Röntgen Museum: The Future}* Ladies and Gentleman, I do not like to close my lecture without inviting you warmly to visit our Museum. I would be very pleased to welcome you all in Remscheid. **I am looking forward for a close British/German partnership.** **Thank you very much for your attention.**

BRIEF BOOK NOTICES

The Chemical elements. The fascinating story of their discovery and of the famous scientists who discovered them. I Necheaf & G Jenkins. Tarquin Publications 1997 (ISBN: 1 899618 11 2)
This account of the discovery of the elements is written in a popular and enjoyable style. Of interest are the accounts of the discovery of the invisible rays by Wilhelm Röntgen and how this led to the discovery of radioactivity by Becquerel and subsequently to the isolation of polonium and radium. I imagine that the book is aimed at school however I greatly enjoyed

reading about all the great names such a Humphrey Davey and Robert Bunsen. Greatly recommended.

New Web Site:

The German Roentgen-Museum now has a web site. The address is:

http://www.roentgen-museum.de

For further details please contact:

Deutches Röntgen-Museum
Schwelmer Str. 41
D-42897 Remscheid
Tel: ++49-2191-62759
Fax: ++49-2191-163145

Opening hours: Tuesday to Friday: 10am-4pm, Saturday and Sunday: 11am-5pm.