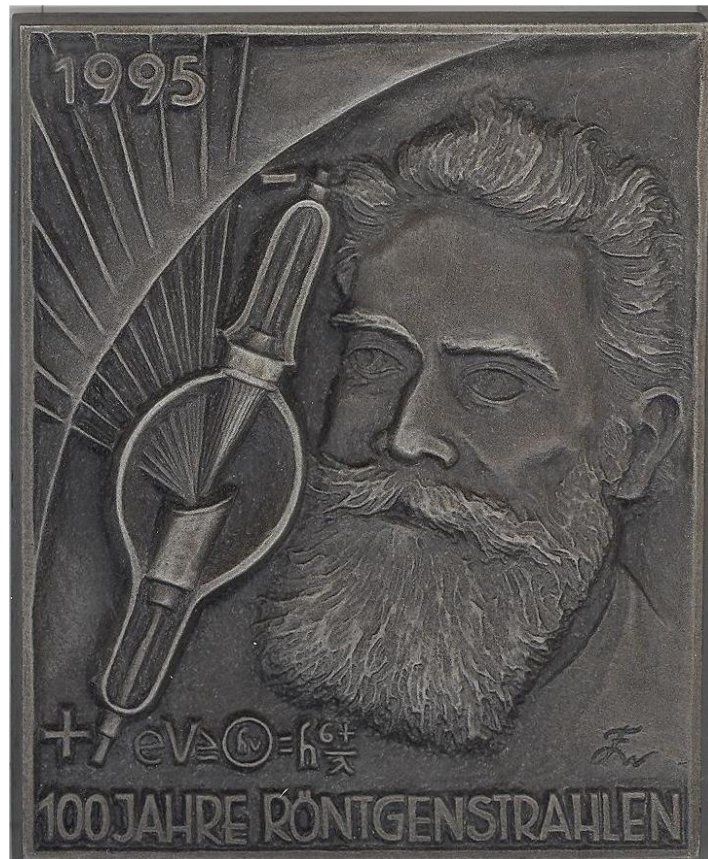


The Invisible Light

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Editorial

I hope you like this issue of The Invisible Light. I am particularly pleased to print a paper by Amy Mitamura from Lone Star College, Cy-Fair Campus in the USA on the 'History of Medical Radiation Safety' which received the 2010 TSRT Competition Award of Merit. Amy is a student in a radiography program in the USA and wrote a research article. Ian Isherwood writes a thought-provoking paper 'The Word – A Duality' which I find particularly interesting in my role as the Honorary Librarian of the British Institute of Radiology. Please send me contributions for the next issue.

The BIR will be visiting the Röntgen Museum in Germany later this year. The Deutsches Röntgen-Museum <http://www.neues-roentgen-museum.de/> is located in Remscheid (Lennep) and celebrates the birthplace of Wilhelm Conrad Röntgen who discovered the X-rays in 1895. There has recently been a major redevelopment of the museum under the skilful hands of Uwe Busch who is the museum's deputy-director (and also a BIR honorary member). I visited the museum after the first part of the redevelopment was completed and was very impressed. The second part of the redevelopment was opened this January. The museum is innovative with many modern exhibits and I would strongly advise a visit. The museum has a huge collection of material relating to X-rays, radiology and Wilhelm Röntgen. The old town of Lennep is quite charming and is worth a visit in its own right.

The visit is planned for the 5-7 November 2010. The flight to Düsseldorf on the Friday morning will take about 1 hour and we would be met at the airport by a coach that would take us to the museum, arriving in time for lunch. The afternoon and evening would be spent visiting the museum and hearing several talks. We can visit the museum and the old town of Lennep on the Saturday and local trips can be arranged. We will return to the UK on the 7th leaving after breakfast. Places are limited to 50 and I would advise early application to avoid disappointment. Please contact me for further details.

I took an intercalated BSc in medical history in 1975 under Prof Bill Bynum at the Wellcome Trust Centre at University College London. I was therefore shocked to learn that on March 31st this year the Wellcome Trust and UCL announced the closure of the Wellcome Trust Centre for the History of Medicine. This decision apparently came in the middle of negotiations concerning the normal

quinquennial review of the funding for the Centre. The proposal to close the Centre was supposedly made by a handful of persons within the Wellcome Trust without, as far as is known, the involvement of any historian of medicine. The Wellcome Trust should reconsider its decision and reinstate the independent peer review process, and should permit any subsequent Centre to remain within the Wellcome building. UCL should maintain the history of medicine as a defined entity within College serving both medical historians and clinicians. The Centre has been the leading international institution for the study of the history of medicine and has created some of the leading scholars within the field. To be closed without peer review is therefore both unjust and unfair. An on-line petition has now been launched and there are already have over 1444 signatures. The Save History of Medicine at UCL Petition to UCL/The Wellcome Trust was created by and written by Professor Vivian Nutton (WCHOMPetition@googlemail.com). If you wish to show your support please sign the petition and circulate it amongst your colleagues. The petition is at <http://www.ucl.ac.uk/histmed/library/petition>

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'Whoever wishes to foresee the future must consult the past; for human events ever resemble those of preceding times. This arises from the fact that they are produced by men who ever have been, and ever shall be, animated by the same passions, and thus they necessarily have the same results.'

Machiavelli

'We can be almost certain of being wrong about the future, if we are wrong about the past'

GK Chesterton

Interesting Recent Radiology History Books and Articles

Radiation and Reason: The Impact of Science on a Culture of Fear (Paperback)

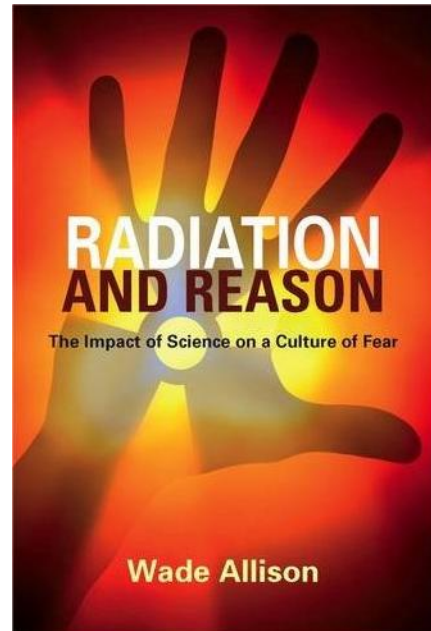
by Wade Allison

Publisher: Wade Allison Publishing (23 Oct 2009)

ISBN-10: 0956275613 ISBN-13: 978-0956275615

Radiation and Reason is written by Wade Allison, an Oxford University professor of physics. The book tells the story of the history and nature of nuclear radiation, and finishes with an attack on the current obsessive safety levels that govern nuclear energy. Wade Allison believes that the regulations overstate the true risk by up to 500 times, which makes nuclear energy prohibitively expensive and hinders the combat of global warming. We have a situation where irrational fears give nuclear power a bad name.

A succession of nuclear crises, starting with Radium toxicity, then the bombing of Hiroshima and Nagasaki and the meltdown of a nuclear reactor at Chernobyl, have created widespread fear and distrust of nuclear power in the public mind. This self-published book by Wade Allison is warmly recommended. The book has a good historical overview and is recommended.



Chernobyl: Consequences of the Catastrophe for People and the Environment

Editors: Alexey V. Yablokov, Vassily B. Nesterenko, Alexey V. Nesterenko, Janette D. Sherman-Nevinger



Alexey V. **YABLOKOV**
Vassily B. **NESTERENKO**
Alexey V. **NESTERENKO**
CONSULTING EDITOR: Janette D. Sherman-Nevinger

ANNALS OF THE NEW YORK ACADEMY OF SCIENCES VOLUME 1181

ISBN: 978-1-57331-757-3

March 2010, Wiley-Blackwell

This interesting book is written by leading authorities from Eastern Europe and outlines the history of both the health and the environmental consequences of the Chernobyl disaster. There has been a great deal of discussion concerning the impacts of nuclear accidents, but never before has there been a comprehensive presentation of all the available information concerning the health and environmental effects of the low dose radioactive contaminants that were emitted from the Chernobyl Nuclear Power Plant. The official discussions emanating from the IAEA and associated UN agencies have largely downplayed or ignored

many of the findings reported in the Eastern European scientific literature and as a consequence these reports have erred on the side of negative findings simply because much of what was known was not

included in their assessments. This new book provides a complete and extensive summary of all known research and provides new insights to the likely long term health and environmental consequences of nuclear accidents.

Die Augen des Professors. Wilhelm Conrad Röntgen - Eine Kurzbiografie

(Taschenbuch)

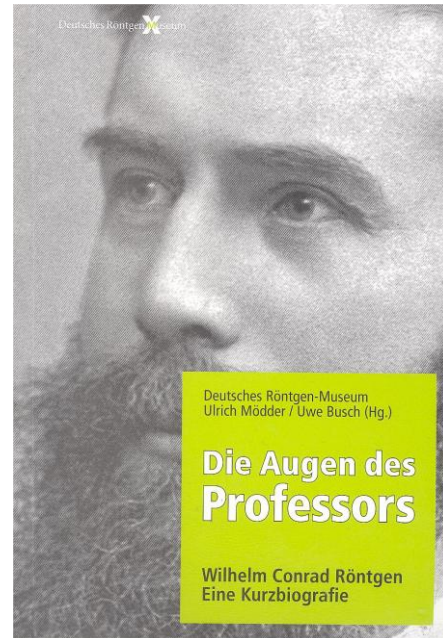
Deutsches Röntgen-Museum: Ulrich Mödder, Uwe Busch & Alexander Schug.

December 2008, Verlag: Vergangenheitsverlag; Auflage

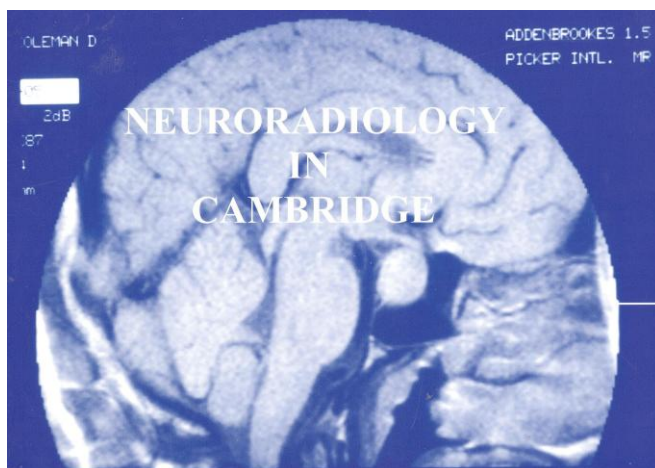
ISBN-10: 3940621021 / ISBN-13: 978-3940621023

Price: EUR 8,90

Prof. Dr. Ulrich Mödder is the director of the Institut für Diagnostische Radiologie, Heinrich-Heine-Universität Düsseldorf and Dr. Uwe Busch is the project manager for the new conception of the German Roentgen museum (Deutsches Röntgen-Museum) in Remscheid; Alexander Schug is a cultural historian. This is a lovely little book and beautifully illustrated. There is at present only a German language version. The book is available either from the museum or from German Amazon.



Neuroradiology in Cambridge.



This book was written by Desmond Hawkins and gives an account of developments in Neuroradiology in the period from 1961 to 2008. Desmond Hawkins was consultant in Neuroradiology in Cambridge from 1960 to 1988. Neuroradiology as practiced in 1988 bore little resemblance to the work in 1960. The book gives a good account of the development of neuro-imaging with some interesting pictures of air encephalography and early CT. It is salutary to realise that

Addenbrooke's Hospital was only able to acquire a CT scanner following a public appeal by the 'Addenbrooke's Hospital Cancer Scanner Appeal' led by a local Councillor who a local Cambridge taxi firm.

Look but do not fix: the pioneers of interventional cardiovascular radiology

Ashis Banerjee. J Med Biogr 17(2): 88—94; doi:10.1258/jmb.2008.008041

This is a most interesting article. It deals with the extension of endovascular radiological procedures to a one-stop combined investigation and treatment of cardiovascular disease which has revolutionized clinical practice. The figures discussed are Charles Dotter, working from Portland, OR, Mason Sones from the Cleveland Clinic and Andreas Gruentzig from Zurich and latterly Atlanta, GA. These pioneers developed procedures that are now routine in interventional radiology.

'The Electrical Expansion of Quartz by Jacques and Pierre Curie' ULTRASOUND November 2009 Volume 17 Number 4

Francis Duck, Medical Physics and Bioengineering Department, Royal United Hospital, Bath BA1 3NG

The history of ultrasound commonly traces its origins to the discovery of the piezoelectric the Curie brothers, Jacques and Pierre. The original papers are commonly cited but are difficult translation. The purpose of this article is to make available in translation their concluding paper, in which the Curies gave a rather more complete description of their work. It is of particular their only paper on piezoelectricity that included figures showing the instruments they had concentrates on the prediction and measurement of the extremely small strains created placed in an electric field. It sets the foundation for the subsequent use and exploitation applications including the first practical transducer for ultrasonic pulse-echo detection.

The Pedoscope

I was contacted by Kirsty Blythe who is a Part 1 Clinical Scientist Trainee (Medical Physics) working at Kings College Hospital. She was then undergoing a 4 month Radiation Protection placement at Guys and St Thomas' Hospitals.



Bruce Walsmley, a Principle Physicist in this department, advised her to contact me regarding an interesting discovery at the Trust. They had recently discovered an interesting device in one of their departments. It was completely decommissioned and non-functional and had been sitting around waiting for somebody to deal with it. The device was a Pedoscope and Kirsty enclosed some pictures of it which are reproduced here. The Pedoscope was used in shoe shops to see an x-ray image of the customer's own feet to judge how well shoes were fitting the customer. Kirsty says that the radiation protection implications of such a device are quite mind blowing to her, as you actually look down a viewfinder directly into the transmitted primary beam as it passes through the own feet and through to a fluoroscopic screen. The device had been sitting in a coffee room for about 30 years, and they wanted to get rid of the device by possibly giving it to a museum or somewhere similar.

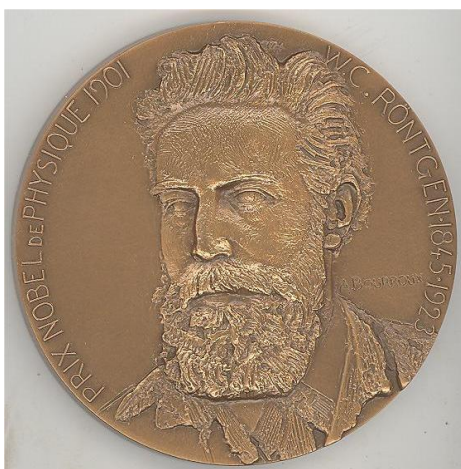


The figure from the front of the cabinet advises: "Have a Pedoscope check – it's a good idea." On the left is shown a well fitting shoe and on the right is a poorly fitting shoe as shown by the Pedoscope. It is interesting to record that the company Wardray received orders for Pedoscope cabinets in the 1950s until they were considered too dangerous to use in shoe shops.

Radiological Medals

I find radiological medals very interesting and some are beautiful. The image on the front cover is a medal struck in 1995 by Buderus Guss GmbH to celebrate 100 years of X-rays. Many medals were produced in 1995.

Röntgen, Nobel Prize, radiation, Bourroux 68mm



This medal was minted in France to commemorate the work of Wilhelm Conrad Röntgen. It was designed by the French medallist, Andre Bourroux and is signed. The front shows a Portrait of Wilhelm Conrad Röntgen, and the reverse shows a symbolic X-Ray picture. The diameter is 68 mm (ca 2¾") and the weight is 197.80 gr, (6.98 oz) and the metal is bronze with a mint patina.

Wilhelm Konrad Röntgen 1845-1923



This medal was produced by 3M in 1973 to commemorate the 50th Anniversary of the death of Wilhelm Conrad Röntgen. Röntgen discovered X-rays in 1895 when he was 50 years old.

Curie Sklodowska, Nobel Prize, Anti-Cancer, Lyceum

This medal has been minted in 1995 in Poland, to commemorate the 50th anniversary of the Maria Sklodowska-Curie Lyceum in Szczecin, Poland. The front shows Maria Sklodowska – Curie and the reverse shows the Lyceum in Szczecin. It measures 70 mm (2¾") and weighs 155.80 gr (5.50 oz) and the metal is bronze with an un-touched patina



Atom Radium Institut Curie: Antoine Lacassagne, Coeffin

This medal was minted in 1964 to commemorate the French physician, biologist and researcher of X-ray treatment of cancers, Lacassagne, Antoine Marcellin Bernard, 1884-1971. 1971). This medal is signed by the eminent French medallist, J. M. COEFFIN.

The front of the medal shows Antoine Lacassagne and the signature of the medallist J. M. Coeffin. The reverse shows the symbolic motives of the Institut du Radium. The diameter is 68 mm, (ca 2¾"), the weight is 146.90 gr, (5.18 oz) and the metal is bronze with an old beautiful patina.

Antoine Lacassagne was born in Villerest in France on August 29th 1884. After receiving a degree in medicine, Lacassagne held various teaching and research positions at the Pasteur Institute, the Radium Institute, and the College de France. In 1937, Lacassagne became director of the biological section at the Radium Institute, a position he was to hold until 1955. In addition to serving as honorary director of the Radium Institute (1955-1971), he was a professor of experimental radiology and experimental medicine at the College de France. In 1957 Lacassagne participated in first meeting of the Pugwash movement, which sought to heighten awareness of the risks for humankind of nuclear weapons. In 1962, Dr. Lacassagne received the United Nations prize for his study of radiation both as a cancer creating agent and as a means of fighting cancer as well as his study of the role of hormones in the disease. He was a member of various scientific academies, among them the French Academy of Science, the National Academy of Medicine and the Academy of Surgery. As reported by the New York Times, Dr. Lacassagne committed suicide on December 15th 1971 at his home in Paris.



There is an Antoine Lacassagne Collection in the University of Tennessee Special Collections Library in Knoxville, TN USA. The Antoine Lacassagne collection houses records of commissions, congresses, conferences, and symposiums, lectures, correspondence, records of experiments, experimental notebooks, lessons, and reprints of publications by Professor Lacassagne and others documenting their work in the field of radiobiology. A significant portion of the collection contains material showing

Professor Lacassagne's research into cancers of different parts of the body and groups of papers concerning various experiments Lacassagne conducted to study the effects of atomic radiation in the treatment of cancer. Call number: MS-0701

Egas Moniz: Nobel Prize Medicine.

This is a bronze Medal Signed by "Aureliano" and it weighs 286 Grs. And has dimensions: 80 x 80 mm. It commemorates the Portuguese radiologist and Nobel laureate Egas Moniz.



Curie Sklodowska Nobel Prize, Nuclear Studies chemistry

This medal was minted in 1980 to commemorate the Polish-French chemist, Maria Curie-Sklodowska and the 25th Anniversary of the Andrzej Soltan Institute for Nuclear Studies in Swierk.

The front shows a portrait of Maria Sklodowska Curie and the reverse the symbol of nuclear power (The inscription is in Polish). The diameter is 75 mm (ca 3"), the weight 164.30 gr, (5.80 oz) and the metal is bronze with a mint patina.

The main site of the Andrzej Soltan Institute for Nuclear Studies is in Swierk near Otwock, about 35 km from the centre of Warsaw and houses four Research Departments, Training and Consulting Department, Establishment for Nuclear Equipment, manufacturer of medical accelerators and Transport Division. The Institute is a state owned Laboratory. It carries out pure and applied research on subatomic physics. It also produces specialized equipment for various applications



THE WORD — A DUALITY?

Professor Ian Isherwood CBE, DSc, MD, FRCP, FRCR, FACR. Emeritus Professor of Diagnostic Radiology, University of Manchester

AJP Taylor once said, "History is about what comes next". Predictions are notoriously unreliable. Lord Kelvin, the doyen of 19th century physics predicted that heavier than air machines would never fly, that radio would never work and that X-rays were a hoax. In 1896 more than 1000 articles concerned with the "new photography" were published and the first radiological journal — "Archives of Clinical Skiagraphy" (later the British Journal of Radiology) produced. Less than 100 years later in 1986, the number of scientific journals in the English language concerned solely with diagnostic radiology had risen to 36 (1), and in the year 2009, the number is still rising. Textbooks proliferate — many in multiple volumes. Together they represent the accumulated knowledge, experience and growth of over 100 years of medical imaging.

Publication in 1542 of "De Humani Corporis Fabrica" — On the structure of the human Body — heralded a new era of communication technology. Vesalius had perceived that the printed textbook could be used to provide reproducible teaching material, albeit at times graphic art against a Paduan landscape. The advent of the microchip and the reality of obtaining both reproducible text and images from digital data has had much the same impact on traditional methods of communication. Enormous computing power is now available in almost every home and office, and libraries like any other social activity of the 21st century have to take cognizance of this, Even so digital data, like graphic art, can have its distractions by its very complexity. Jonathan Swift accused cartographers in the 17th century — "With savage pictures fill their gaps and, o'er uninhabited downs, place elephants instead of towns".

In that Georgian era before the development of scientific medicine, medical awareness was not the exclusive preserve of the doctor. There was a common medical language and a common medical culture between doctor and patient. This attitude changed, perhaps in the late 19th century, as George in "Three Men in a Boat" discovered in the public library, that he suffered from every known condition other than housemaid's knee. By the mid 20th century, Sir Lancelot Pratt was more likely in the public's mind to represent the medical establishment. Roy Porter (2) reviewing the Gentleman's magazine a journal published from 1731-1907 observed the wide range of medical reviews, correspondence and remedies. The magazine was neither proprietorial nor didactic but permitted a free exchange of medical information. Quackery was, of course, rife. Pills, powders and potions for self medication were widely available and widely advertised throughout the Victorian era. Indeed by 1896 anyone might, with relative ease, construct and use a device capable of producing X-rays and human images. The Manchester Guardian, founded in 1820, devoted one fifth of its advertising space to patient remedies. My Victorian grandmother's door mat declared in bold letters "Parkinson's Pink Pills for Pale People". Medical knowledge was an open culture with decisions made almost by a tribunal of physician, the educated and the opinion makers from society at large. The Circulating Library with current news and a reading room for the literate proprietors became popular. Many such were both literary figures and physicians, Mark Roget for example. "How beautiful to a genuine lover of reading are the sullied leaves and worn out appearance of an old Circulating Library book", wrote Charles Lamb. "How they speak of the thousand thumbs that have turned over their pages with delight - who would have them a whit less soiled? What better condition could we desire to see them in?"

The explosion in bioscience research has created a huge demand for up to date medical information, specialist journals, books and the facilities to accommodate them. The number and cost of journals has increased whilst the finance available has decreased. As a consequence in most university, medical school and specialist libraries there have been extensive reductions in the number of journals purchased — sometimes over 10% per annum. Increased numbers of medical students, the introduction of problem based learning in medical schools and new degree courses for other health professionals have only served to intensify the pressure. In one major LN university library an additional 2 km of shelving is required every year!

The solution appears to lie in the electronic format and a number of libraries are adopting this approach with the installation of clusters of personal computers providing access to email, the Internet, software packages and electronic databases, but there are significant constraints. Is the electronic format a complete substitute for hard copy? Could a large central library of books with a diminishing number of journals be a viable option for the 21st century? Information technology and the World Wide Web have certainly spread across the entire planet with astonishing speed over the last decade, transforming our lives and providing opportunities to trawl endlessly through medical and scientific literature, to exchange information and to educate. But where does this leave the conventional textbook and the hard copy journal? Some have argued that the rise of information technology enabling a "virtual library" may dispense with the need for a large conventional central library and that the proliferation of CD ROMs providing instant access to text and annotated image might even displace the book as we know it. Others have claimed that projects such as PubMed Central organized

by the United States National Institutes of Health will make the results of original research freely available to all via the Internet. Certainly many practicing radiologists and postgraduate students already find it adequate for their needs to access an electronic database from the convenience of their office or their home. The case for a central database for the radiological trainee of the future, for example, seems at first compelling. Yet the counter arguments are equally, if not more, persuasive. Electronic data need considerably more professional management than printed media. Researchers can jump from one article to another at the click of a mouse often with accompanying 3D interactive animations. The "virtual publishers" generate their own problems of access, copyright and cost. Copyright has been redefined to enforce payment whenever a text is read. What price intellectual property rights for authors? Annual subscriptions to electronic journals provide only for access rather than for purchasing a physical object to keep on the shelf. Cancellation of a subscription to an electronic database can result in loss of access to archival material and electronic data cannot easily replace a primary printed archive. Will the publishers continue to provide paper texts in the years ahead?

Individual authors can now present their data on the Internet without peer review. In the last 5 years several completely electronic journals have appeared and almost every paper journal now has an online version. Many books are available online and also in electronic book format the size of a paper back but containing multiple books. A touch on the screen turns the page. Not quite what Harold McMillan had in mind when he said he enjoyed going to bed with a good Trollope. Most electronic journals are mounted on servers operated by the publishing industry and accessed through the Web allowing the publisher to add features and take on functions traditionally performed by librarians (3). As software changes can the subscriber rely on the durability of electronic data? Perhaps the only enduring form of medium is print (4). Will commercial interests permit continuous access? Are we prepared, intellectually and financially, for the deluge of data presently accumulating? (5).

What does cybermedicine mean in medico legal terms? The Internet has been transformed from a research and educational domain to a global market for health services with instantaneous access for both doctor and patient. Cybermedicine is affecting healthcare and the laws relating to it, notably in the United States and particularly in relation to regulation, quality and confidentiality of information (6). Health law usually differentiates between a doctor, an institution and a manufacturer. Organisations that have become separated in the 20th century, the doctor and the drug supplier for example, are being reintegrated by the Internet enabling comparison shopping by patients and the opportunity for the quackery of the 18th and 19th century to re-emerge. As e-services increase so diagnostic services are appearing offering free medical advice, sometimes by personalized interactive sessions. The patient may possess down loaded web pages offering the same, or sometimes even better, information than the doctor has, or can obtain. The patient may demand a specific diagnostic test, a specific treatment or a referral to a specialized centre. Such a situation can, of course, be advantageous to both doctor and patient and provide the opportunity for a new partnership for high quality health care (7).

Confidentiality and patient privacy are under threat. Any electronic communication between doctor and patient, or between doctor and doctor, must be secure and preferably encrypted. In addition the identities of all parties concerned must be assured — a concept at odds with the supposed anonymity of the Web. Is the adviser a qualified doctor? Is the patient genuine? The General Medical Council advise that standards of care can be compromised where the patient is not previously known to the doctor and that giving online advice to patients creates a duty of care such that the doctor can be held to account for such advice. These alarming trends away from personal medical care pose serious problems not only for those with the Internet but more especially for those without it — and also for the future development of medical libraries and the provision of access to them.

It seems essential that a form of dualism must prevail in the libraries of the immediate future enabling both text and electronic data to co-exist. Each must have meaning to the recipient.

Keats wrote in his Ode to a Nightingale:-

"Was it a vision or a waking dream

Fled is that music

Do I wake or sleep?"

Coleridge on the other hand complained that nightingales were as numerous as frogs and, combined with his indigestion, only served to keep him awake at night.

Charles Lamb perhaps expressed dualism of publication best:-

-There are two classes of men, those who borrow books and those who lend them"

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History of Medical Radiation Safety

Amy Mitamura, Lone Star College, Cy-Fair Campus (2010 TSRT Award of Merit Competition)

Medical imaging has become such a routine part of everyday life that few of us take into consideration the impact these inventions have had upon the course of day to day life. X-rays and the subsequent technologies it has spawned have not only been celebrated and vilified but studied and



Figure 1: First x-ray of Frau Roentgen's hand

debated by laymen and governments alike. The now familiar hazards of ionizing radiation had a long path to become publicly recognized and have systems for dealing with them put into place. The following will examine the culture of discovery that surrounded the birth of the x-ray and see how it impeded early calls for safety measures as well as the creation of the first safety standards.

In December 1895, Wilhelm Karl Roentgen published his finding regarding a new kind of ray. This paper and a remarkable picture of his wife's hand (Figure 1) would ignite the imagination of the world. Scientists sought to recreate and understand these new rays. Businessmen searched for ways to market everything from x-ray portraits to equipment. Doctors saw immediate potential for determining where foreign objects lay in the body. Theologians debated over how to incorporate their discovery into the fabric of late nineteenth century life. However, no one at the time thought to question their safety. Why should they, after all? How harmful could light be? In an era of scientific cause and effect, the dark side of x-rays couldn't be foreseen. Electricity was dangerous, but immediately so. Mysterious diseases were now visible to everyone via new technologies. Roentgen's rays were invisible, tasteless and odourless; just another kind of light.

It was in this era of scientific naiveté that Roentgen's x-rays emerged onto centre stage. "X-ray Boy's Clubs spouted in the United States, and X-ray slot machines were installed in Chicago and Lawrence, Kansas, where, for a coin, you could examine the bones in your own hand" (Kevles, 1998, p. 25). Even more incredibly, x-rays became acceptable evidence in a court case just two months after Roentgen's paper was published. George Holder was convicted of shooting Tolson Cummings, the first

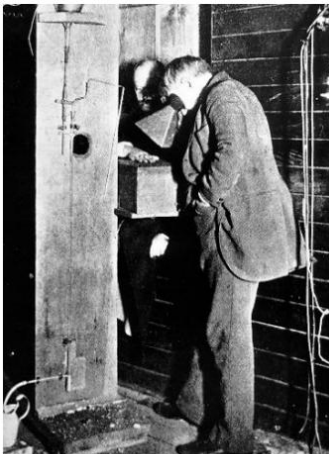


Figure 2: Edison using fluoroscopy machine

ever use of an x-ray image as evidence (Kevles, 1998, p. 30). In March 1896, a scant three months after the discovery of x-rays, the first labs in hospitals began using them (Fenster, 2003, p., 31). Thankfully, x-rays were mostly regarded as a curiosity and thus not often used as a diagnostic tool for many years to come. In addition, early exposures took anywhere from fifteen minutes to several hours to produce and were too time consuming for general purpose use.

One of the early innovators leap onto the x-ray stage was Thomas Alva Edison. Already known for his electric vote recorder, phonograph, kinoscope and lights bulb, Edison and his team began improving upon Roentgen's work. Edison was in a perfect position to

do so as the Crooke's tube that Roentgen used in his initial experiments closely resembled Edison's light bulbs. In short order Edison and his team had developed a working fluoroscopy model (Figure 2) which he proudly displayed at the Electrical Exhibition in New York City's Grand Central Station in April of 1896. Ever the showman, Edison set up a darkened room lit only by two red lamps which cast a mysterious glow upon the room. Patrons were given a coin to hold in a clenched fist which they could then view through his wondrous fluoroscopy machine (Kevles, 1998, p. 28). Edison's involvement with the new ray had the additional effect of lending scientific credence and popular excitement to the endeavour. By the next year, Edison was marketing fluoroscopy kits for the home hobbyist (Caufield, 1989, p. 6).

With all the excitement and experimentation with x-rays, it wasn't long before the first signs of danger began to emerge. Within three years of the discovery of x-rays, reports of hair loss (epilation), lightening of the skin, reddening of the skin (erythema) and strange lesions that failed to heal were being reported from several sources around the world. Physicians and beauticians, with what now resembles creative and wilful stupidity, began using these effects to their advantage spawning x-ray treatments for hair removal, acne treatments and the erasure of birth marks. Researchers at the College of Chemistry at the University of Chicago even began the appalling but short lived experiment of bleaching the skin of black people (Kevles, 1998, p. 29).



Figure 3: Clarence Dally



In 1904, x-rays claimed its first victim. Clarence Dally (Figure 3) was Edison's main assistant who helped with the development of fluoroscopy. He was in the habit, as were many experimenters of the time, of holding objects being x-rayed with his bare hands. Dally first noticed burns on his face, followed by the loss of all his hair and lesions that would not heal on his left hand. He continued to

work with Edison using his right hand to hold objects. Soon the condition spread to his right hand as well. Edison became increasingly alarmed by the state of his assistant and swore off the x-ray bandwagon altogether. It was too late for Dally, who continued to suffer from oozing ulcers, tried skin grafts to no avail and eventually had both arms amputated. Pained by watching his friend die by inches with increasing and unrelenting pain, Edison consulted doctor upon doctor. "The strangest part of all," lamented Edison, "Is that all this is the result of work with the X-ray five or six years ago and now comes this result" (Kevles, 1998, p. 48).

Other early x-ray pioneers suffered similar fates. By the early 1900's amputated limbs became the unofficial badge of the x-ray worker. One meeting of a Roentgen Society meeting was marred by an embarrassing mistake. At dinner, roast chicken was served but not one member among them had a second arm in which to use their knife. One of the first to document the damaging effects of x-rays was Mihran Kassabian. Doctor Kassabian did extensive work with fluoroscopic radiographs at the Medico-Chirurgical Hospital then the U.S. government and was eventually appointed director of the Roentgen-Ray Laboratory at the Philadelphia Hospital. In 1900 he began documenting his own battle



Figure 4: Mihran Kassabian's hands 1903

with the effects of his life's work. "About five months ago, the fingers, knuckles and dorsum of my left hand exhibited a general erythematous condition (Figure 4). This continued about a month; the itching became intense, the skin became tough, glossy, edematous and yellow" (Brown, 1995, p. 1287). Over the next several years Kassabian continues to write with increasing despair, searching for a way to lessen the pain, heal the lesions, help his colleagues as much as himself. Kassabian

died of cancer in 1910 at the age of forty. His is thought to be the first cancer death directly attributable to x-rays.

The first proponent of radiation safety was William Herbert Rollins. A Boston dentist, Rollins suffered from a severe burn while experimenting with x-rays in 1898. He began extensive testing of x-rays on guinea pigs and was alarmed at the scope of damage they produced on living tissue. He determined that prolonged exposure could cause burns, hair loss and even death. Further, he noted that x-rays could cause infertility and cause pregnant guinea pigs to abort. With these catastrophic effects in mind, he established three safety precautions: wearing radiopaque glasses, enclosing the x-ray tube in a leaded housing and limiting the x-ray beam to the area of interest (Harris, 1995, p. 9). Rollins discovered that he could mask off adjacent areas by covering them with sheets of radiopaque material such as lead. This eventually led Rollins to construct the first collimation devices, but he never patented or marketed his invention. Rollins' warnings went largely unnoticed, partly because of Rollins himself. A reticent man who shunned public interaction, he did not present his findings at any of the newly flourishing Roentgen Societies. He did publish his findings, but they were mostly limited to dental journals and failed to capture the attention of the wider medical community.

Another safety pioneer was Rome Vernon Wagner. At a 1907 meeting of the American Roentgen Ray Society he reported that a technique he used to control his radiation exposure was to carry a photographic plate in his pocket during the day. At the end of the day he would develop it to see how much exposure he had acquired by the amount of fog on the film. This forerunner to the modern film badge did not come into widespread practice for many years. Unfortunately, by the time Wagoner had come to his innovation it was too late. He was already suffering from cancer and died in 1908 (Kathern).

With the mounting evidence of the dangers of x-rays, it seems, in retrospect, baffling that the scientific community did not take it more seriously. It is important to realize that without standard technical equipment, many of the burns were attributed to the machines themselves. Poor insulation on wires was common and many users of electric devices were accustomed to shocks and electric burns. Electrical power itself was relatively new and random surges were frequent. Also, there were a huge number of makers of x-ray devices and new tubes and machines were being introduced onto the market at a high rate. Burns were often attributed to "older" style machines or the wrong sort of x-ray tube. Other theories for damage abounded. Nikola Tesla, known for inventing the electric alternating current, believed that the electrical charge around the tube produced ozone. Tesla

theorized that when ozone came in contact with skin it caused damage. "Other theories included infectious material on the skin's surface, platinum particles from x-ray tubes, and the static current of charges induced in the tissue by the induction field surrounding the x-ray tube" (Harris, 1995, p. 10).

In 1914, WWI erupted across Europe and put x-ray technology to a practical test. Renowned Nobel Prize winning physicist, Marie Curie was appointed Director of the Red Cross Radiology Services. She along with her daughter, Irene, put together scores of technicians and mobile x-ray units that could travel to the battlefield. These vehicles and their wondrous machines, christened Petite Curies by the soldiers, served to save innumerable lives by quickly allowing doctors to locate and remove bullets and shrapnel as well as diagnose and set broken bones (De Burgh, 1989, p. 2178). With the dire need of x-rays, the new technologists came to the profession quickly and without much training. Safety took a back seat to the more immediate problems presented by war. When peace was finally declared, concern grew over the continuing health problems of servicemen and medical professionals alike.

This lack of understanding concerning the dangers of x-rays culminated in a 1920 civil suit filed against St. Luke's Hospital in Little Rock Arkansas. Two years previously, Mr. and Mrs. Goodrum took their daughter, Mamie, in for a fluoroscopic exam of her back. What should have been three exams lasting for four seconds each, ended up lasting forty minutes a piece. Apparently, the technician got carried away with explaining the procedure to the parents and ended up exposing Mamie to a total of 120 minutes of x-rays. Little Mamie ended up with severe burns that resulted in permanent scarring from neck to waist. The technician, Mrs. Chamberlain, testified that patients often complained of a burning sensation even before the current was turned on and she therefore had always felt that patient complaints were invalid. She went on to say that she herself had been x-rayed many times and never experienced any burning so it must not exist. Further, a radiologist explained that every person had a different temperament when it came to skin burns and that x-rays were by nature unpredictable. The implication being that the child must have willed the burns upon herself by means of her poor "temperament" and insufficient moral character. It was her own fault that she had been burned said the defence. The jury agreed and Goodrums lost both their initial case and their appeal two years later (Kevles, 1998, p. 82).

Despite the Goodrum case, by the 1920's it was becoming increasingly obvious that x-rays, unpredictable or not, would have to be studied further for safety considerations. The number of amputations, cancers and deaths of radiographers drew the attention of the biggest compiler of death statistics in the world, the insurance companies (Caufield, 1989, p. 15). Worried by the increasing number of reported cases of radiation injuries and fatalities, the medical community began to research ways of reducing exposure. The British X-Ray and Radium Protection Committee formed in 1921 with the intention to formulate guidelines for the manufacture and use of x-ray equipment and devices to eliminate the chance of occupational injury. Their main obstacle was that there was no real way to measure radiation doses. From 1900 to 1920 the accepted unit for exposure was the skin erythema dose (ED). This is the quantity of radiation needed to cause "diffused redness over an area of skin after irradiation" (Sherer 46). Not only was this a very inexact measurement as this dose varies from person to person and the area of irradiation, but its meaning differed from doctor to doctor. In addition, skin

erythema occurs only after an extremely high amount of radiation. Modern calculations put an erythema dose to equal to several hundred rems (Radiation or Roentgen equivalent man).

At the University of Indiana, Hermann Muller began conducting experiments on fruit flies that would eventually earn him the 1946 Nobel Prize in Medicine. Muller discovered that x-rays could cause sterility and genetic mutations in the fruit flies. More alarmingly, these mutations carried over to the next generation. It was the first indication that radiation could cause damage at the chromosomal level. Newspapers jokingly reported that families would suddenly start producing a random red headed child in dark haired families (Caufield, 1989, p. 109). Years later in Nazi Germany, these findings would lead to experiments in creating Hitler's master race. These efforts were soon abandoned due to the more harmful effects but restructured to a different effect. The tendency for x-rays to cause infertility was studied as a means of mass castration. They intended to use x-rays to secretly sterilize those unwanted members of society (Proctor, 1999, p. 90).

In the 1920's the accepted unit of exposure was the roentgen. However, the roentgen was not adequately defined. In 1924 Arthur Mutscheller, a physicist working for an x-ray manufacturer, set about trying to devise a method for measuring how much radiation humans could tolerate. He polled several doctors to see if they had suffered any ill effects. Since none of them had, he concluded that they must be receiving a tolerable dose. Since there were currently no machines that could measure radiation he devised a largely arbitrary formula. He multiplied the electrical current powering the x-ray machine by the length of the exposure and divided the result by the square of the distance between the subject and the source. Mutscheller then converted it to erythema dose units (ED) by multiplying his end result by 36.5—a number he picked because he felt it gave the right answer. From this, it was concluded that 0.02 ED per month was an acceptable limit. Mutscheller's conclusion was given credence by two separate researchers in Sweden and Britain who came to very similar numbers through equally sketchy logic. It was this research that, in 1933, led the U.S. Advisory Committee on X-Ray and Radium Protection (ACXRP) to adopt 0.02 as the newly created tolerance dose, measured in roentgens per day, as its first official limits on radiation for safety purposes (Caufield, 1989, p. 18).



Figure 5: X-Ray Martyr Monument

Setting limits on radiation dosages, scientifically researched and internationally verified, gave a sense of security to the industry. Certainly the science behind the amount was dubious, but setting limits—any limits—was essential. Those advising the government felt that there was no time to wait for better research. By the 1930s there had been so many deaths of the first generation of x-ray technicians and doctors that the German Roentgen Society constructed a monument to the x-ray martyrs in Hamburg (Figure 5). It was originally carved with the names of 136 victims. Over the next 30 years several hundred more names were added as the latent damage due to cancers came to collect their victims (Caufield, 1989, p. 21). Setting limits also brought an end to the innocent days of science. The age of the atom bomb was fast approaching. No longer

could anything, not even a new kind of ray, be looked upon with complete innocence. Illness, death and destruction could also be reaped from scientific marvels.

When Roentgen first discovered his new kind of light, he could not have imagined what innovations it would lead to. However, that innovation has come with a high price. The effects of ionizing radiation on biological systems is severe and of a lasting nature. Protection against its effects is now well established thanks to the efforts, and in many cases, the lives of those who came before. Today as imaging technologies become ever more common, it is up to the integrity of current and future technologists to learn from the past, to adhere to safety protocol of the present and find new ways to insure the well being of themselves and their patients.

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