The Discovery

- On November 8th, 1895, Wilhelm Conrad Roentgen was working in his laboratory in Wurzburg, Germany, using Crooke's tubes. In the darkened laboratory, he noticed that a sheet of cardboard, placed several feet away, was glowing in the shape of the letter A that a student had painted in liquid barium platinocyanide.

- He noticed that the effect was fluorescent, that is, the glow stopped if the current was interrupted or the rays were blocked. Further, he discovered that different materials attenuated the beam differently.
Roentgen then isolated himself in his laboratory for the next seven weeks. From his carefully crafted experiments, much of what is known about the physics of x-radiation was derived.

The first radiograph – Mrs. Roentgen’s hand.

In those seven weeks, Roentgen discovered that:
- although the new rays were invisible, they caused fluorescence in certain substances
- they darkened photographic plates
- they were propagated in straight lines
- their behavior differed fundamentally from that of cathode rays
- they were neither reflected nor refracted by (then known) experimental methods
- they were not deviated by the influence of electro-magnetic fields
- air traversed by the rays was made electrically conductive
- He investigated the startling penetration of the rays through many materials and observed the “hardening” of x-ray beams after penetrating several absorbers
- He noted that different types of scattered and of secondary radiations were produced

Source: http://compepid.tuskegee.edu/syllabi/clinical/small/radiology/chapter2.html

On December 28th, 1895, Roentgen presented his findings to the Wurzburg Physical-Medical Society. He presented several radiographs, including the one of his wife’s hand. By January 1896, word of his discovery had spread throughout the world.
This radiograph of the hand of Albert von Kolliker was made by Roentgen during the lecture and demonstration at the Wurzburg Physical-Medical Society on January 23, 1896. Note the similarity to the radiograph of Mrs. Roentgen’s hand!

Enter Dentistry

In January 1896, a dentist in Braunschweig, Germany made the first dental radiograph. Using a glass photographic plate wrapped in black rubber dam and with an exposure of 25 minutes, Dr. Otto Walkoff produced this intraoral radiograph.

Enter Dentistry

- This radiograph was made on February 1st, 1896 by Dr. Walter König of Germany.

Enter Dentistry

- It is thought that the first dental radiograph made in the United States was by Dr. Edmund Kells of New Orleans, Louisiana.

Enter Dentistry

Dr. Kells in his office in 1926. Note the damage to his left arm and hand.
Enter Dentistry

Dr Kells used impression compound to stabilize the film during exposure.

Roentgen’s Apparatus

This is a German Ruhmkorff mini coil from the beginning of the 20th Century.

Roentgen’s Apparatus

Roentgen originally used a variation on the Hittorf-Crooke’s tube, developed by Philipp Lenard. Lenard placed a small window of thin aluminum foil over an opening in the tube. This allowed the cathode rays to escape the tube more readily, as the current was applied. The surprise was that the fluorescent effect occurred while using the heavier-walled Hittorf-Crooke’s tube.

Roentgen’s Apparatus

Cathode Ray

From Wikipedia

Cathode rays are streams of electrons observed in vacuum tubes, i.e. evacuated glass tubes that are equipped with at least two electrodes, a cathode (negative electrode) and an anode (positive electrode) in a configuration known as a diode. When the cathode is heated, it emits some radiation which travels to the anode. If the inner glass walls behind the anode are coated with a phosphorescent material, they glow. A metal shape placed between the electrodes casts a shadow on the glowing coating. This suggested that the cause of the light emission was comprised of rays emitted by the cathode and hitting the coating. They travel towards the anode in straight lines, and continue past it for some distance.
The Nobel Prize 1901

From the “I could’ve been a contender” Department...

The “I could’ve been a contender” Department

- On February 22nd, 1890 in Philadelphia, PA, A.W. Goodspeed and William Jennings produced this radiogram by placing the coins on top of a glass photographic plate. The coins and plate were exposed to radiation via a Hittorf – Crooke’s tube. Had they realized the significance of their findings, they would have beaten Roentgen to the discovery of X-rays by more than 5 years. Additionally, early radiographs might have been called “goodspeedograms.” This proves that sometimes things are better off as they are!

Radiogram from 1890

February 22nd, 1890 A.W. Goodspeed and William Jennings

Contemporaries

Lenard also experimented with Hittorf - Crooke’s tubes and, undoubtedly, produced X-rays, but did not immediately grasp the importance of the finding. He resented Roentgen throughout his life. In 1933 he joined the National Socialist Party (Nazis.) He rose to the rank of Chief of Aryan Physics.

Philipp von Lenard 1862 – 1947


Contemporaries

From 1885 to 1889 Hertz became the first person to broadcast and receive radio waves, and to establish the fact that light was a form of electromagnetic radiation. Experimented with cathode rays. (Gugliemo Marconi didn’t begin his own wireless experiments until 1894, based on the earlier work of Hertz, Maxwell, and others.) Hertz probably would have gone on to make many more scientific contributions, but he died quite young, less than a month before his 37th birthday.

Heinrich Rudolf Hertz 1857-1894

Source: http://www.ideaarchive.com/history/inventors/hertz.htm
Cathode Ray Tubes

The Cross Vacuum Scale demonstrates the phenomenon of discharge at different pressures (vacuum) inside the tubes. The pressures vary between 40 Torr (mmHg) lowest vacuum (left tube) to 0.03 Torr, the highest vacuum (right tube.) In this high vacuum, used in many Crookes tubes, X-Rays are produced. The glass emits here a green glow.

Source: The Cathode Ray Tube site

Timeline Leading to Roentgen's Discovery

300 Years of Discoveries Leading to Roentgen's Work

- 1600 Gilbert's (1540-1603) De Magnete created the foundation for the sciences of magnetism and electricity.
- 1675 Newton (1643-1727) built a more efficient electrostatic generator with a rotating glass sphere.
- 1729 Gray (1696-1736) distinguished conductors of electricity from nonconductors.
- 1750 Franklin (1706-1790) defined positive and negative electricity.
- 1785 Morgan (?-1785) in vacuum experiments, possibly produced X-rays.
- 1800 Volta (1745-1827) constructed the first electrical battery, the Voltaic pile.
- 1820 Oersted (1777-1851) discovered the link between electricity and magnetism.
- 1827 Ohm (1787-1854) formulated Ohm's law, stating the relation between electric current, electromotive force, and resistance.
- 1827 Faraday (1791-1867) and Henry (1797-1878) discovered electromagnetic induction.
- 1829 Plucker (1801-1868) observed green-glass fluorescence opposite the negative electrode in a vacuum tube.
- 1834 H. G. B. von Zwillings and Wiedemann improved electrostatic machines.
- 1840 Balmer (1810-1865) published his famous equations in the book, "Treatise on Electricity and Magnetism."
- 1845 Ohm (1787-1854) published a second volume to his work on electricity.
- 1850 Plucker (1801-1868) found that cathode rays can be deflected by a magnet, and believed that he was dealing with a "fourth state of matter."
- 1853 H. G. B. von Zwillings and Wiedemann found that cathode rays can be deflected by a magnet, and believed that he was dealing with a "fourth state of matter."
- 1856 H. G. B. von Zwillings and Wiedemann found that cathode rays can be deflected by a magnet, and believed that he was dealing with a "fourth state of matter."
- 1892 Lenard (1862-1947) built improved cathode-ray tubes and made important observations on the properties of cathode rays.

Source: http://compepid.tuskegee.edu/syllabi/clinical/small/radiology/chapter2.html

Niels Bohr (1885-1962)

William Morton (1845-1920)

- New York dentist
- Also credited (along with Kells) with the first dental radiograph exposed in the United States
- Wrote a book on X-rays in 1896

William H. Rollins (1852-1929)

- Boston Dentist
- Publish more than 200 articles on radiation effects and safety between 1896 and 1904
- "Notes on X-Light", published in 1904 called for radiation protection for radiation workers and patients

Source: The Radiology Centennial Collection
The Rollins Collimator

This collimator is the forerunner of our rectangular collimators!

William H. Rollins

- Alas, Rollins was ignored by his colleagues, much to their detriment. It was not until atomic bombs were exploded over Hiroshima and Nagasaki that dentistry took a serious look at radiation safety.

Dr. Frank Van Woert (1856-1927)

- Dr. Van Woert was another pioneer of oral and maxillofacial radiology. He made a practical demonstration of dental radiography before the New York Odontological Society in 1897. He was one of the first to use Kodak film (instead of glass plates). These were wrapped in rubber dam and held in place with compound. He later invented a metal film holder, an improved bisecting angulator, an automatic timing switch, and the daylight processing tank.

Howard Riley Raper (1886-1978)

- Dr. Raper had one of the first oral and maxillofacial radiology offices (as opposed to a laboratory). He was the inventor of the bitewing radiograph in 1924, the first to introduce oral and maxillofacial radiology into the dental curriculum (in 1910 at the Indiana Dental School), and the first to write a textbook on the subject (Elementary and Dental Radiology, 1913).

Early dental x-ray unit

- The G.E. CDX was the first modern type dental x-ray unit on the market in 1921. Others soon followed.
Early dental x-ray unit
• Picker dental unit from the 1930’s

The Dangers
• Hand-held fluoroscopes were used in the 1890’s. Early radiologists measured the "erythema dose" to their hands!

The Dangers
• Radiologists and their assistants routinely used hand-held fluoroscopes to check out the x-ray tubes each morning. Output varied tube by tube, as each was handmade and the properties varied.

The Dangers
• Although many had noted difficulties associated with "X-ray burns," it was not until the death of Clarence Daily (1865-1904), Edison’s longtime assistant in X-ray manufacture and testing, that observers finally agreed that the magic rays could kill as well as cure.

The Dangers
• Dr. Edmund Kells, an early pioneer of oral radiology, paid a tragic price for his work. When, at age 40, he first began his work with X-rays, he was unaware of the unseen danger of cumulative doses of radiation. He often held the films in place with his own fingers. By the time Kells reached 50, he had developed cancer in his right hand. Over the next 20 years, Kells endured 42 operations. He lost, progressively, his hand, his arm, and his shoulder.

Source: http://www.ac.cc.md.us/dental/98-1newsletter/EdmundKells.html
The Dangers
- In spite of agonizing pain, 42 operations, and numerous skin grafts, his 20-year battle against the ill effects of the exposure from dental X-rays was about to come to an end.
- Throughout the trauma, Kells still served the profession. He lectured on preventive dentistry and the conservation of teeth. He wrote books, and he contributed over 150 articles to dental journals. At last, however, Kells suffering became intolerable. On May 7, 1928, at age 72, he committed suicide.

Source: http://www.ac.cc.md.us/dental/98-1newsletter/EdmundKells.html
http://clarionherald.org/20000427/stall.htm

“...it's unearthly, it's downright mystical.”
Wilhelm Conrad Roentgen

Postscript
- Röntgen had family in the United States (in Iowa) and at one time he planned to emigrate. Although he accepted an appointment at Columbia University in New York City and had actually purchased transatlantic tickets, the outbreak of World War I changed his plans and he remained in Munich for the rest of his career. Röntgen died in 1923 of carcinoma of the bowel. It is not believed his carcinoma was a result of his work with ionizing radiation because his investigations were only for a short time and he was one of the few pioneers in the field who used protective lead shields routinely.

Source: http://en.wikipedia.org/wiki/Wilhelm_R%C3%B6ntgen#Early_life_and_education

Roentgen published a total of 3 papers on x-rays between 1895 and 1897. None of his conclusions have yet been proven false.

Source: http://en.wikipedia.org/wiki/Wilhelm_R%C3%B6ntgen#Early_life_and_education

Thank you!