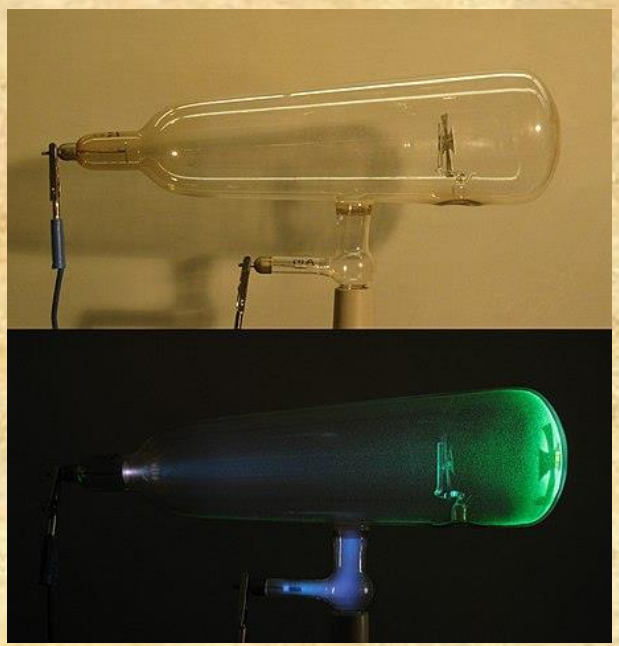
C24 The Timeline of Radiologic Discovery and Invention

Objectives

- Explain the discovery of X-ray
- Give examples of the early uses of X-ray in the medical field
- Explain the repercussions of unsafe use of radiation
- Present some of the advancements with radiation in the modern era

The accidental discovery of X-ray: Wilhelm Röntgen

In Röntgen's laboratory in the Würzburg Physical Institute of the University of Würzburg, Röntgen was investigating the external effects of passing an electrical discharge through various types of vacuum tube equipment. It was through one of Philipp von Lenard's inventions that Röntgen added aluminum to permit cathode rays to exit the tube. Röntgen observed that the cathode rays caused a fluorescent effect on a small cardboard screen. The screen was painted with barium platinocyanide. It occurred to Röntgen that the Crookes-Hittorf tube might also cause this fluorescent effect.

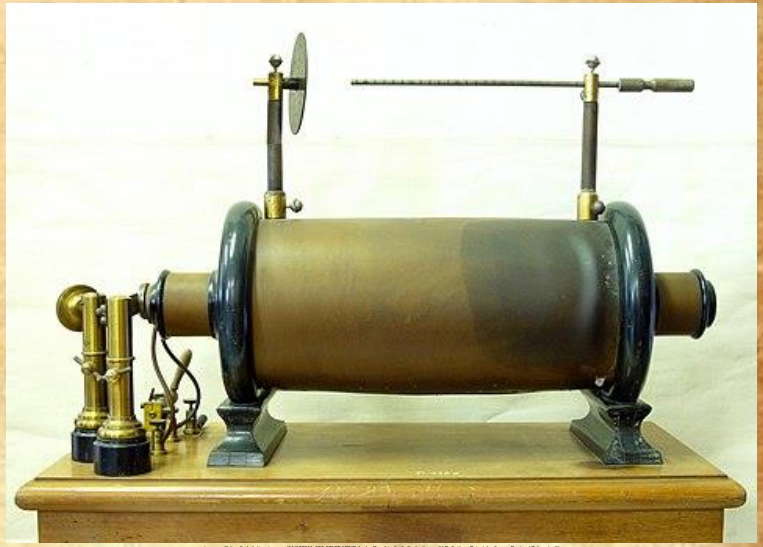


Crookes–Hittorf tube

8 November 1895, early morning

The accidental discovery of X-ray: Wilhelm Röntgen

Determined to test his Idea on fluorescent effects, Röntgen created a light tight tube and tested the Ruhmkorff coil charge through the tube. It was immediately after this that he noticed a faint shimmering from a bench a few feet away from the tube. He tested the coil several more times to insure that the same thing shimmered each time. It did. The item was a barium platinocyanide screen. Over the next couple of weeks Röntgen tested different materials to see their effects. Röntgen brought a small piece of lead into position while a discharge was occurring. He then saw the first radiographic image: his own flickering ghostly skeleton on the barium platinocyanide screen.



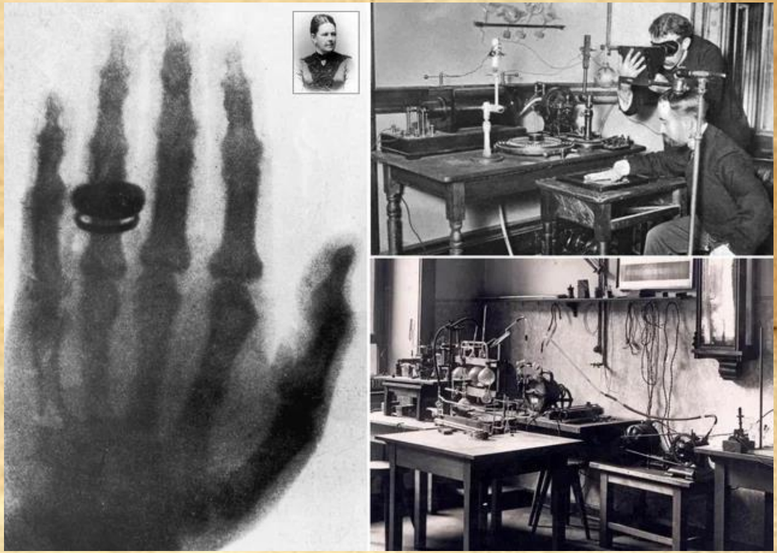
Ruhmkorff coil

8 November 1895, early morning

8 November 1895, late afternoon

The accidental discovery of X-ray: “I have seen my death”

About six weeks after his discovery, he took a picture, a radiograph, using X-rays. The picture was of his wife Anna Bertha's hand. When she saw her skeleton she exclaimed "I have seen my death!" He later took a better picture of his friend Albert von Kölliker's hand at a public lecture. Thus inventing x-ray imaging.



8 November 1895, early morning

20 December 1895

8 November 1895, late afternoon

Early uses of X-ray: Discovery and Experimentation

The first use of X-rays under clinical conditions was by John Hall-Edwards in Birmingham, England, on 11 January 1896, when he radiographed a needle stuck in the hand of an associate.

On 3 February 1896 Gilman Frost, a professor of medicine, and his brother Edwin Frost, a professor of physics, exposed the previously fractured wrist of Eddie McCarthy to X-rays. They collected the image of the broken bone on a gelatin photographic plate.

On 14 February 1896, Hall-Edwards also became the first to use X-rays in a surgical operation

These 3 events are what pioneered the use of X-ray in the medical field.

First Clinical X-ray in America Performed

8 November 1895, early morning

20 December 1895

11 January 1896

3 February 1896

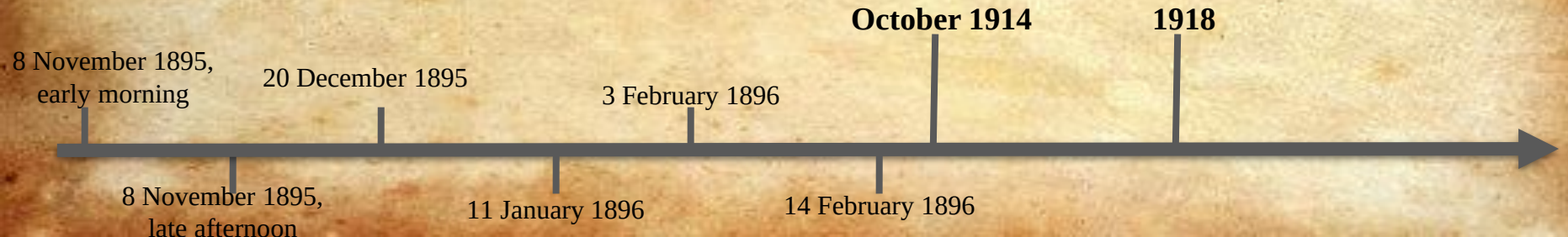
14 February 1896

8 November 1895, late afternoon

Early uses of X-ray: World War I

In October 1914 Marie Sklodowska, better known as “Madam Curie,” received funding to bring 20 vehicles equipped with x-ray equipment into the war. In order to power these x-ray machines she used the trucks’ engines. Before this there was no way to bring these machines onto the front lines as there was never enough power. She helped establish 200 stationary Base Hospitals. She was able to maintain a consistent electricity source to the x-ray machines on the rear of the battlefields because of this. She helped lead the way for radiology to help on the war front.

Edward Holman Skinner was an M.D. who served as the x-ray specialist at Base Hospital # 28 in 1918. There he reviewed approximately 3,601 x-rays. Reviewing these images was a challenge, do to the compromised photo-techniques of the x-rays, and because of the primitive x-ray techniques. There was not a consistent energy level of the radiation, no coning or consistent positioning, fogging of the glass plates occurred from the scatter radiation, and evaluation of soft tissue and vessels was severely limited. He brought to light the need for consistency in imaging.



Early uses of X-ray: World War I (images dictated by Edward Holman Skinner)

Chest X-ray
There are metallic foreign bodies overlying the heart, lower lobe of the left lung, spleen, liver, and left shoulder. The hyperlucent left lung may be a reflection of a pneumothorax.

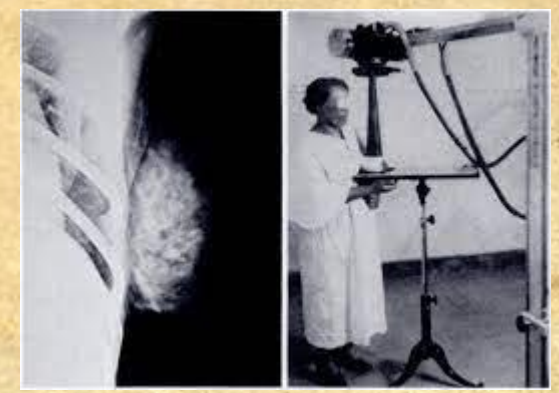
Extremity X-ray
There is a severely comminuted distal humerus fracture with metal foreign bodies around the fracture site. The elbow is not visualized.

Skull X-ray
Severely distorted anatomy and compromised film technique and positioning. This appears to reveal markedly comminuted mandibular fractures with teeth displaced into the mouth.

Early uses of X-ray: Mammography

In 1930 Stafford Warren founded the clinical use of breast radiography in the United States. He reported a stereoscopic technique to describe and classify the appearances of normal breasts, identifying fatty and glandular types, as well as illustrate the changes involved with pregnancy, mastitis, and benign and malignant tumors. Helping to diagnose breast cancer in a way that was safer and easier for women.

By 1938 Gershon-Cohen and Strickler noted that a base line must be acquired before a true diagnosis could be made. This was done because breast tissue is different for each woman. He helped to create a way form women to get regular check-ups to better catch the early development of cancer.



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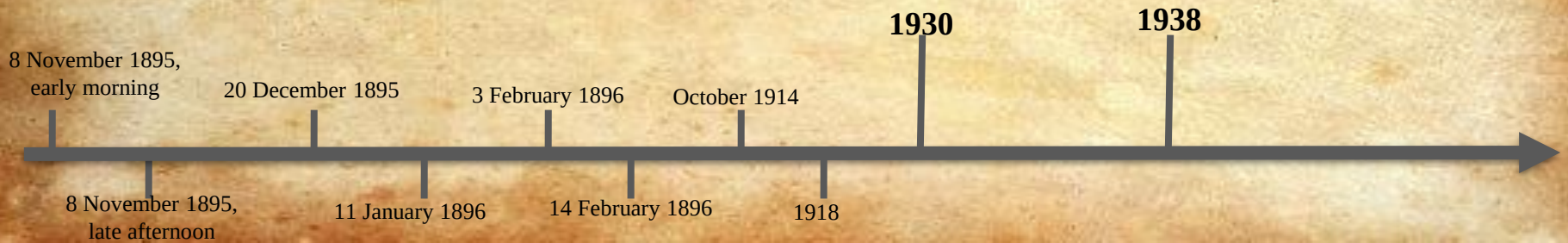
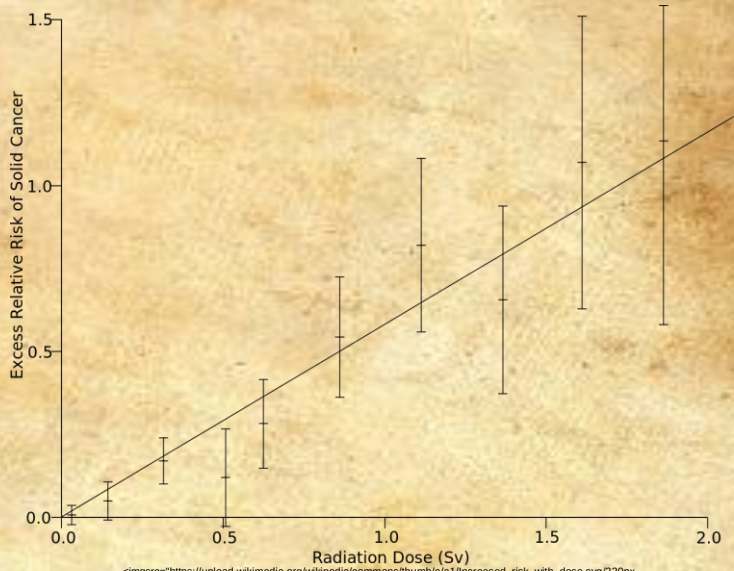
An image of a breast (left) and the machine used to take the image (right)



Repercussions of unsafe use of radiation

Following the dropping of the atomic bomb on Japan on the 5th of August 1945, Hermann Joseph Muller became the topic of conversation. Though he had already tested and discovered the quantitative connection between radiation and lethal mutations in 1926 it was not until 1946 that Muller was awarded the Nobel Prize in Physiology or Medicine. He was awarded this for the discovery that mutations can be induced by X-rays. In Muller's Nobel Prize lecture, he argued that no threshold dose of radiation existed that did not produce mutagenesis. Leading to the adoption of the linear no-threshold model. This model explained that no dose of radiation is a safe dose. This model is still used today for imaging and calculating the risks of each dose.

linear no-threshold model



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November 1946

8 November 1895, early morning

8 November 1895, late afternoon

20 December 1895

11 January 1896

3 February 1896

14 February 1896

October 1914

1918

1930

1938

Repercussions of unsafe use of radiation: Radiation Safety

Following World War II considerations for radiation protection were provided by the information gathered from the wartime research. These included concepts of absorbed dose, dose-equivalent, and relative biological effectiveness.

In 1948 the British X-ray Radium Protection Committee suggested a maximum permissible dose (MPD) of 0.5 R per week (R =Roentgen, a unit for measuring radiation dosage).

This number was later lowered in 1958 by the National Council on Radiation Protection and Measurements (NCRP) to 0.3 rad per week max.

These numbers became one of the first ‘shields’ used to help protect the imager and the patient from radiation in the medical field.

Table 2.

Chronology of external whole-body occupational radiation protection standards

1934	IXRPC	0.2 R/d (60 rem/y)	International X-ray and Radium Protection Commission[70]
1934	NCRP	30 rem/y at 0.1 rem/d	NBS Handbook 18
1937	IXRPC	0.2 R/d (60 rem/y) 1 R/wk	International X-ray and Radium Protection Commission[78]
1950	ICRP	15 rem/y at 0.3 rem/wk	NBS Handbook 47[79]
1954	NCRP	3 rad/13 wk 0.3 rad/wk max 15 rem/y	NBS Handbook 59[80]
1958	NCRP	3 rad/13 wk 0.3 rad/wk max 15 rem/y 5(N-18) rem accumulated	NBS Handbook 59 addendum[81]
1958	ICRP	0.1 rem/wk three rem/13 wk 5 (N-18) rem accumulated	ICRP Publication 1[82]

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7446021/

Repercussions of unsafe use of radiation: Radiation Safety Cont.

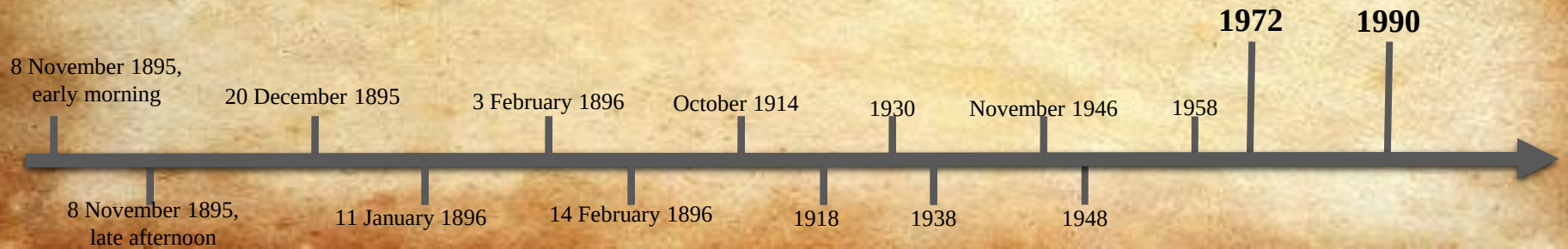
In 1972 CT imaging was invented at the British EMI laboratories by Godfrey Hounsfield and Allan Cormack. While it introduced a fast multislice imaging system it also greatly increased the dose given to the patient.

By the early 1990s the use of fluoroscopy guided procedures increased and because of this the reports of fluoroscopically induced skin injuries reappeared after an absence of more than 50 years.

It was these main 2 events that led to the ICRP (International Commission on Radiological Protection) and the NCRP recommending these 3 guidelines:

Guidelines:

1. No image should be taken unless the needs of it out way the risks of taking it
2. All exposures should be kept as low as reasonably achievable
3. The dose equivalent should not exceed the limits recommended

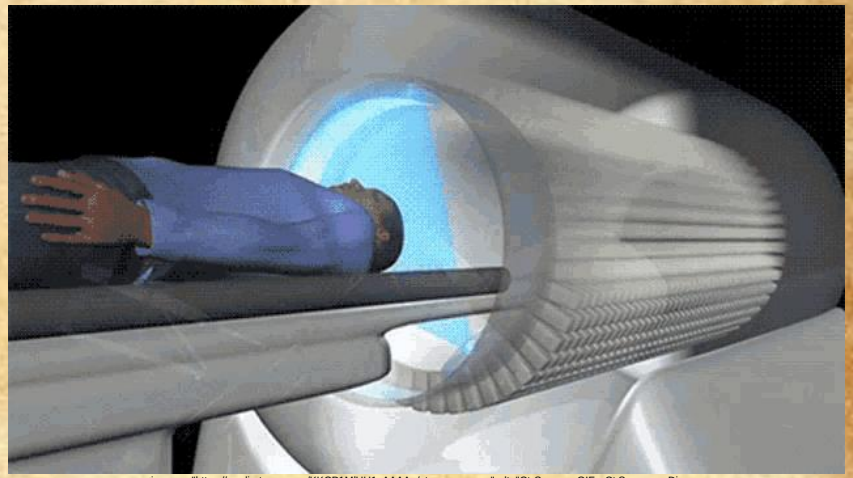


The advancements with radiation in the modern era: CT & MRI

Although it was first approved to be used in a medical setting in 1973 it was in 1980 that the popularity of CT images (computed tomography) reached a staggering height of 3 million CT scan examinations being recorded that year.

Similarly to CT scanning, MRI (magnetic resonance imaging) was approved for medical use in 1984, but it did not become popular until 1993 when it became faster and more effective. There were still only 10 scanners in America at the time but the quality image it created with a lack of radiation was a game changer.

Both of these imaging modalities helped to better understand the human body and to diagnose pathologies that would have otherwise been missed with regular x-ray.

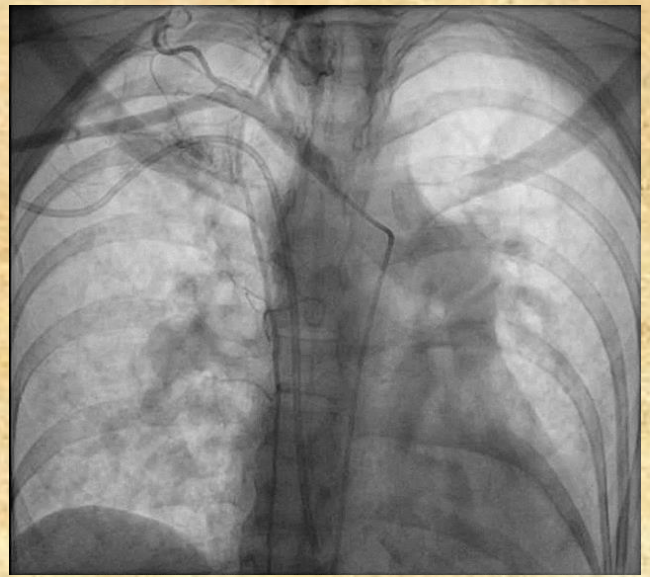


CT scanner

The advancements with radiation in the modern era: IR

Interventional Radiology is a subspecialty of diagnostic radiology that involves the use of CT and ultrasound to help aid doctors in minimally invasive surgical procedures that diagnose, treat, and cure many kinds of conditions. Though first proposed in 1963 by Charles Dotter it was not until 1994 that Vascular and interventional radiology was recognized by the American Board of Medical Specialties (ABMS) as a subspecialty of diagnostic radiology.

It is through this modality that over 1,000 stroke victims were saved in May of 2022 alone.



Contrast viewed under fluoroscopic guidance to show blood flow

8 November 1895, early morning

8 November 1895, late afternoon

20 December 1895

11 January 1896

3 February 1896

14 February 1896

October 1914

1918

1930

1938

November 1946

1948

1958

1972

1980

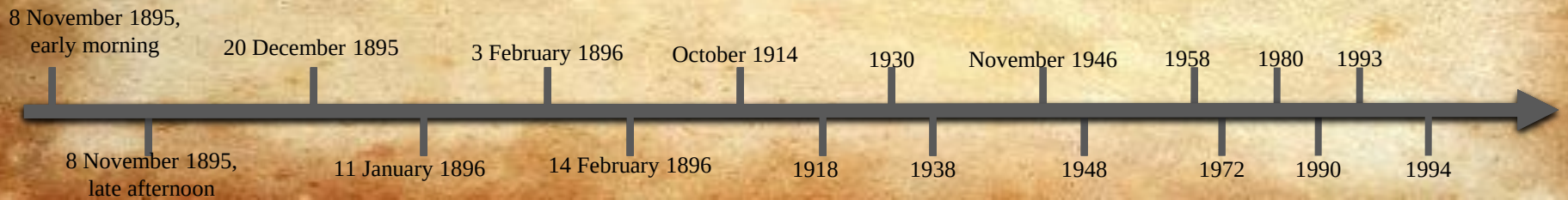
1990

1993

1994

Conclusion

As we have seen the history of radiology is extensive and filled with progress, as many great discoveries have been made over the years. From interventional radiology to computed tomography, magnetic resonance imaging and mammography; many of these advancements were discovered through trial and error. Over the years safety precautions were created and implemented with regard to war time experimentation. The primary governing body being the National Council on Radiation Protection and Measurements who assist in minimizing the negative effects of radiation. All of this progress would have had little chance of advancement had it not been for the chance discovery on the 8th of November in 1895.



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