Office of Environmental Safety

Baylor College of Medicine®

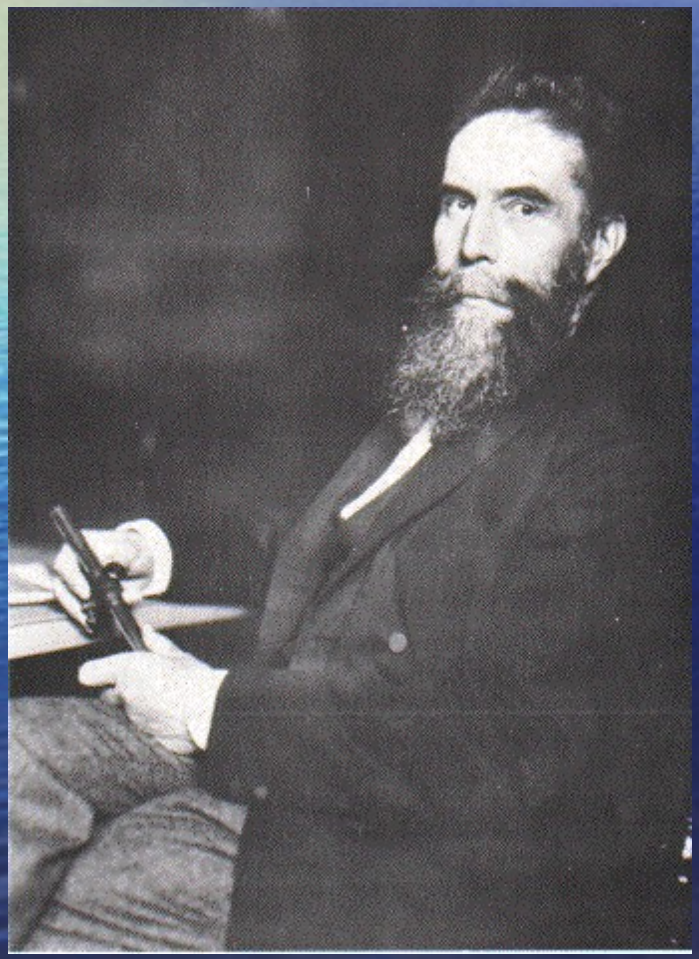
GIVING LIFE TO POSSIBLE

Objectives

By the end of this training, you should be able to:

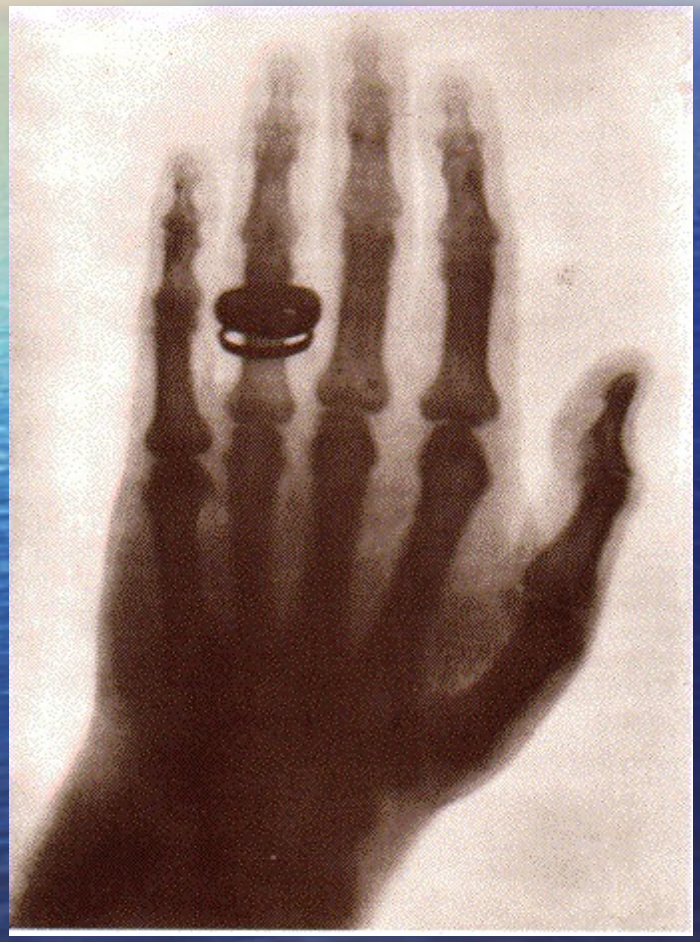
- Describe a brief history of X-ray Machines
- Identify the hazards associated with working with X-rays
- Gain a deeper understanding of X-ray Machines

In The Beginning ...



- On 8 November 1895, Wilhelm Konrad Roentgen discovered the X-ray.

The First X-ray

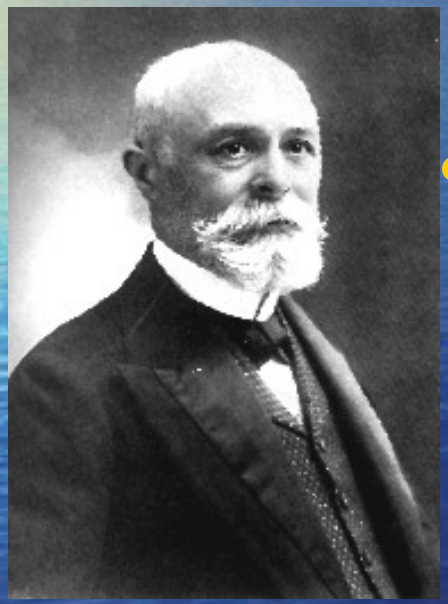


On 22 December 1895, Dr. Roentgen made the first X-ray photograph (Frau Roentgen's hand).

The Aftermath

- On 1 January 1896, Roentgen announced his discovery to the world.
- 14 February 1896, four days after news of the discovery reached the U.S, X-rays were used to guide surgery in New York.
- In early 1896, the Italian military began using X-rays to diagnose and treat wounded soldiers

At the same time ...



- In February 1896, Henri Becquerel discovered natural radioactivity.

Recognizing the Hazards

- Jan 1896: The first radiation burns were reported
- Nov 1896: Elihu Thompson intentionally exposed his little finger to radiation over a period of a few days and then cautioned against over exposure "… or there may be cause for regret when too late."
- Becquerel and Pierre Curie both suffered abdominal burns from carrying vials of radium in their vest pockets.

Early Protection Recommendations

- Between 1896 and 1899, William Herbert Rollins proposed almost all of the protective measures now employed in X-ray systems.
  - Shielded tube housings
  - Collimators
  - Pulsed fluoroscopy
  - Filtration
- In 1896, Thomas Edison cautioned against the continued use of X-rays and abandoned his own research in this area.

Standard Organizations

- 1925: The First International Congress on Radiology meets in London.
- 1928: The Second International Congress on Radiology meets.
- 1929: The Advisory Committee on X-ray and Radium Protection is founded (Later becomes the National Council on Radiation Protection and Measurement (NCRP)
- 1950: The International Congress on Radiology changes its name to the International Commission on Radiological Protection (ICRP)

Regulatory Agencies

- 1946 & 1954: The Atomic Energy Act of 1946 and the 1954 amendments to the Act establish the Atomic Energy Commission (AEC) to regulate source, special nuclear, and by product material.

- 1959: The Federal Radiation Council is organized to control non-AEC materials.

Early Exposure Limits

- Early 1920s: No more that 7 hours per day, with Sunday and two half-days per week off performing X-ray procedures.
- Mid 1920s: 1/100 of the erythema dose in any 30 day period (works out to about 72 rads/yr).
- Early 1930s: 50 R/yr
- Late 1930s: 25 R/yr
- 1950: 300 mrem/week (15 rem/yr) deep dose and 600 mrem/week (30 rem/yr) shallow dose
- 1959: 5 rem/yr (ICRP)

Recent Dose Limits

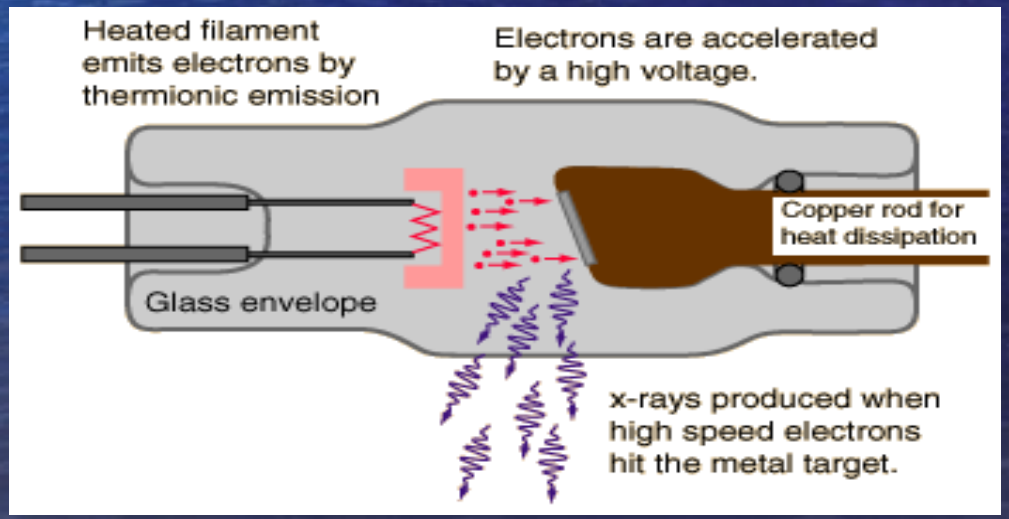
- 1977: ICRP recommends 5 rem/yr including internal exposures
- 1990: ICRP recommends 2 rem/yr averaged over 5 years with no single year exceeding 5 rem.
- 1994: NRC adopt 1977 recommendations.

X-ray Machines

- What are X-rays?
  - Form of electromagnetic radiation which arises as electrons are deflected from their original paths
  - Are capable of traveling long distances through air and most other materials
  - Require more shielding than beta or alpha particles to reduce their intensity
  - X-rays and gamma rays differ primarily in their origin
    - X-rays originate in the electronic shell
    - Gamma rays originate in the nucleus

X-ray Machines

- An X-ray tube requires
  - a source of electrons
  - a means to accelerate the electrons
  - a target to stop the high-speed electrons



X-ray Machines

- Analytical X-ray usage:
  - Diffraction [XRD]
    - X-ray scattering from crystalline materials. "fingerprint" of crystalline atomic structure. Check known library vs. unknown sample.
  - Fluorescence [XRF]
    - Analytical method for determining the elemental composition of a substance.

X-ray Machines

- Hazards of Analytical X-ray Equipment
  - Exposure to the primary beam
  - Leakage or scatter of the primary beam through cracks in ill fitting or defective equipment
  - Penetration of the primary beam through the tube housing, shutters or diffraction apparatus
  - Diffracted rays

X-ray Machines

- Causes of Exposure During Analytical X-ray Use
  - Putting fingers in X-ray beam to change sample
  - Aligning X-ray beam visually
  - Modification of shielding
  - Failure to realize X-rays are emitted from several ports
  - Failure to read & follow manufacturer's X-ray operating instructions

Any of these actions could cause an unnecessary exposure and a potential negative effect!

X-ray Machines

- Medical Diagnostic X-rays
  - Radiography – a picture with film or a digital image is sent directly to a computer screen
  - Fluoroscopic – a real time "moving" inspection on inside bodily functions imaged on a screen

- **Diagnostic radiology** is the branch of medicine that has traditionally been known for taking and reading X-rays. Diagnostic radiology is the nucleus of almost every physician's diagnosis. Being able to detect disease sooner and pinpoint its location more accurately is a huge factor in stopping disease in its tracks.

X-ray Safety

- All operating personnel must be intimately familiar with the principles of operation, principles of radiation safety, and potential general and specific hazards of their particular machine.
- Radiation surveys must be made annually, whenever beam-target or specimen-detector geometry is changed, or whenever shielding arrangements are altered and after maintenance work.

X-ray Safety

- Master-switch keys and secondary keys should be in the possession of the first person entering an exposure room, and that person should be the last to leave the room.
- Situations which require interlocks to be temporarily disabled require prior approval of the Radiation Safety Officer.

X-ray Safety

- All radiation producing equipment must have clearly visible warning lights to indicate when the equipment is generating radiation.
- Warning light systems should be configured to indicate when a light is not operational.

X-ray Safety

- All operating personnel must be properly badged with individually assigned personnel dosimeter devices.
- Not all situations of X-ray machine use, such as self-shielded cabinet type units, require dosimetry. Contact OES for details.
- Approved warning signs indicating the nature of the hazards must be posted at entrances to hazard areas, and the instrument console must be posted with a plaque indicating the nature and quality of the radiation produced.

X-ray Safety

- Machines require a regular check by a state-licensed medical physicist depending on the nature of use; e.g. human use-annually, veterinary use-every 5 years, etc.
- Radiation dose to members of the public/non-radiation workers in the vicinity of such machines generally cannot exceed 100 mrem/year except in the case of certain medical offices where a 500 mrem/year limit is applicable.
- Contact OES concerning questions of shielding and area monitoring.
- Unusual operations or unexpected machine behavior must be reported to the Radiation Safety Office immediately.

X-ray Safety

- X-ray Effects
  - The effects of X-ray exposure depend upon:
    - Duration - How long the dose is delivered.
    - Energy - How much energy was in the X-ray
    - Low Energy (<50 KeV) - damage only to skin or outer part of body
    - High Energy - damage to internal organs
    - Total Dose - The magnitude of the dose

X-ray Safety

- Unsafe Conditions
  - Access door interlocks do not work
  - Shielding has been damaged
  - Viewing window of shielding is cracked.

- **IF AN UNSAFE CONDITION ARISES WITH YOUR X-ray DEVICE:**
  - Stop work!
  - Turn power OFF to X-ray (An X-ray requires power to produce radiation)
  - Notify your Principal Investigator and BCM Radiation Safety @ 713-798-4799

X-ray Safety

- Radiation Protection-Time:
  - The radiation dose that a worker receives is directly proportional to the amount of time spent in the radiation field.
  - For example, reducing the time of exposure by one-half will reduce the radiation dose by one-half. Users need always to work quickly and limit time spent next to X-ray equipment while it is operating.

X-ray Safety

- Radiation Protection-Distance:
  - Radiation exposure decreases rapidly as the distance between the worker and the X-ray device increases.
  - The decrease in exposure from a point source, such as an X-ray tube, can be calculated by using the inverse square law.

X-ray Safety

- Radiation Protection-Distance:
  - This law states that the amount of radiation at a given distance from a point source varies inversely with the square of the distance.
  - For example, doubling the distance from an X-ray tube will quarter your exposure; increasing the distance by a factor of three will reduce the dose to one-ninth, etc.

X-ray Safety

- Radiation Protection-Distance:
  - Maintaining a safe distance represents one of most effective methods for reducing radiation exposure.
  - Using the principle of distance is especially important when working around open beam analytical X-ray equipment and medical fluoroscopes.

X-ray Safety

- Radiation Protection-Shielding:
  - Radiation exposure to personnel can also be reduced by placing an attenuating material between a worker and the X-ray tube.
  - The energy of the incident X-ray photon is reduced by Compton and photoelectric interactions in the shielding material.
  - Thus, substances such as lead, that are very dense and have a high atomic number, are very practical shielding materials because of the abundance of atoms and electrons that can interact with the X-ray photon.
  - Lead aprons, booths and rolling shields are examples of shielding that are often required.

X-ray Safety

- Radiation Protection-Shielding:
  - Shielding is often incorporated into the equipment, such as the metal lining surrounding the X-ray tube.
  - It may also consist of permanent barriers such as concrete and lead walls, leaded glass, and plastic movable screens in the case of analytical X-ray equipment.

X-ray Machine Examples

X-ray tube in a collimated lead housing

Mobile shield for the operator

Control panel where the operator can select X-ray ON (exposure) time in fraction of minutes, the energy of X-ray (in kVp) and current applied (higher current = more X-rays).

X-ray Machine Examples

When this “C-arm” X-ray device is used the operator and support staff MUST wear a lead apron, safety glasses and whole body dosimeter badge.

X-ray Machine Examples

Small compact “totally enclosed” research X-ray devices which generally require little special monitoring.

X-ray Machine Examples

X-ray diffraction unit. Care must be taken here because while the beam is small, it can be quite intense and produce a severe Burn.

Additional Training

- Please make sure you have also completed Radiation Safety Training which is offered every 2nd and 4th Wednesday of the month from 9-12 in room 201A of the Cullen building
- If you have any questions please contact the RSO, Susanne Savely at 713-798-5268

Thank you!

Please remember to take the quiz by clicking on the “take test” button on your screen