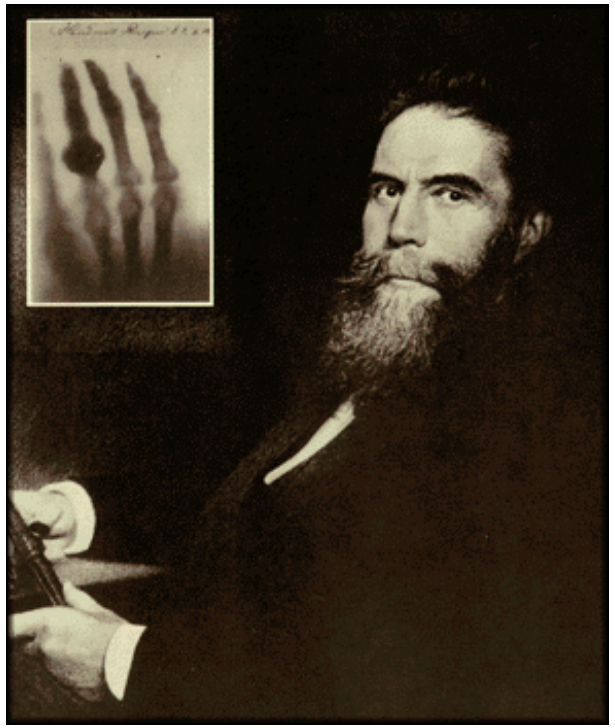
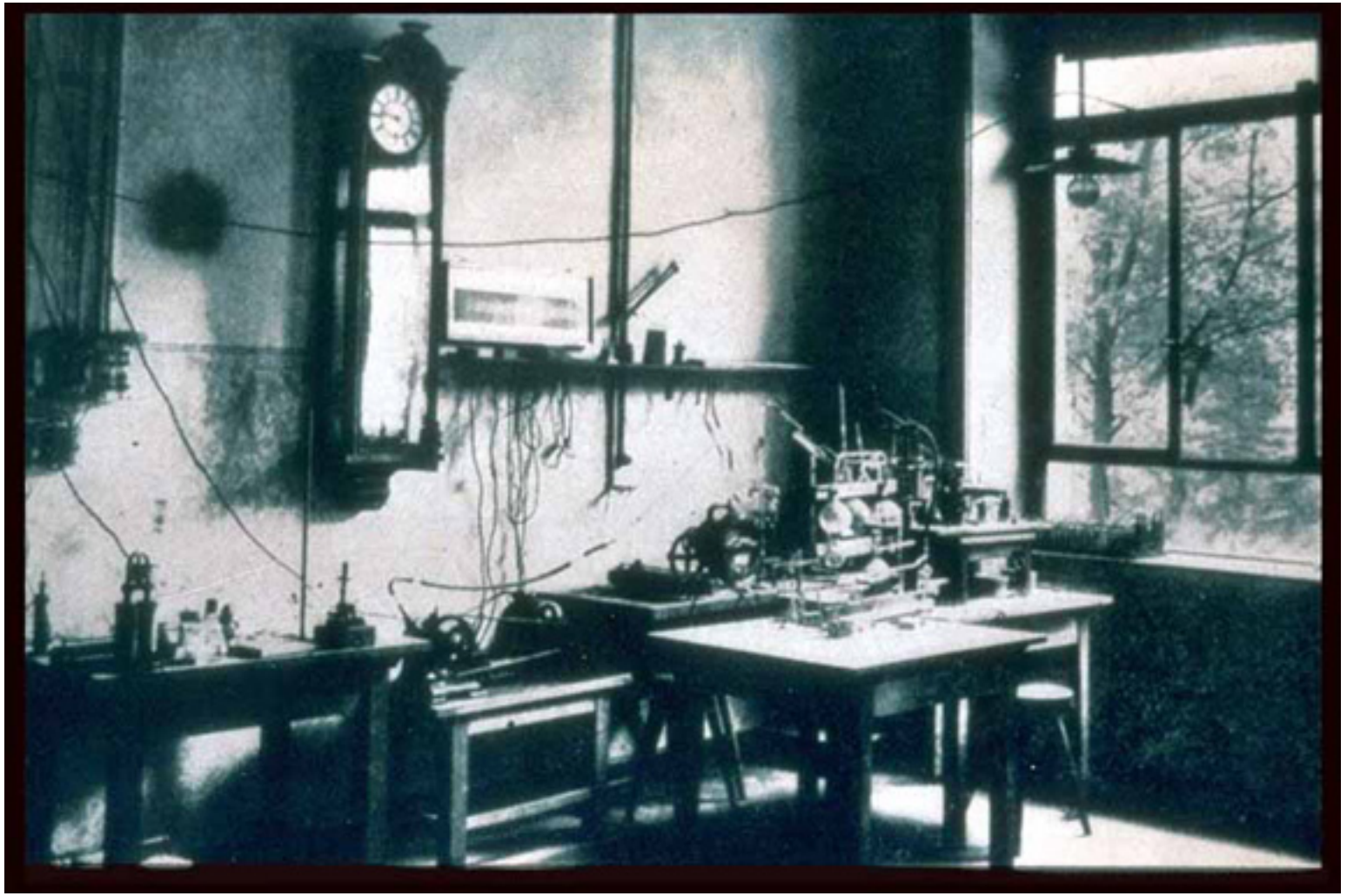
# X-rays



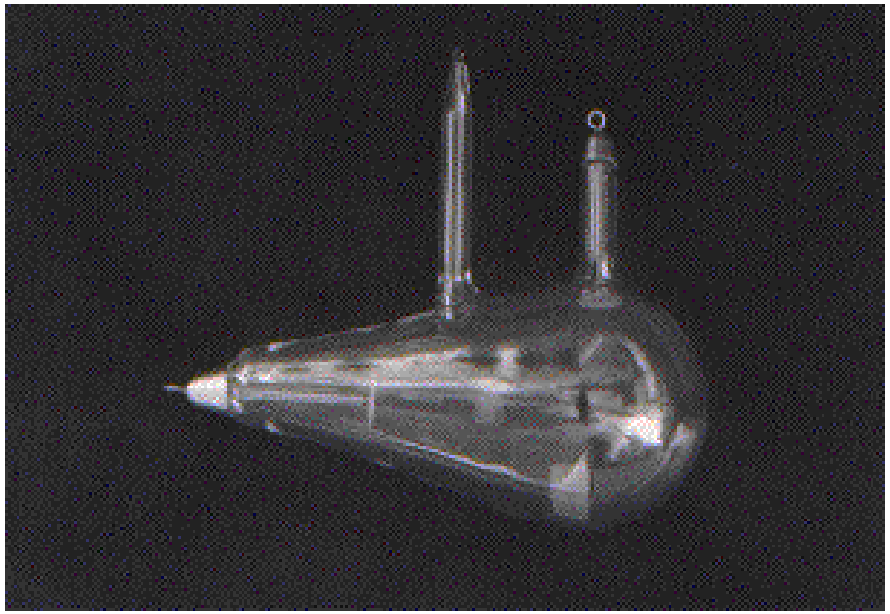
Roentgen and famous picture of his wife's hand

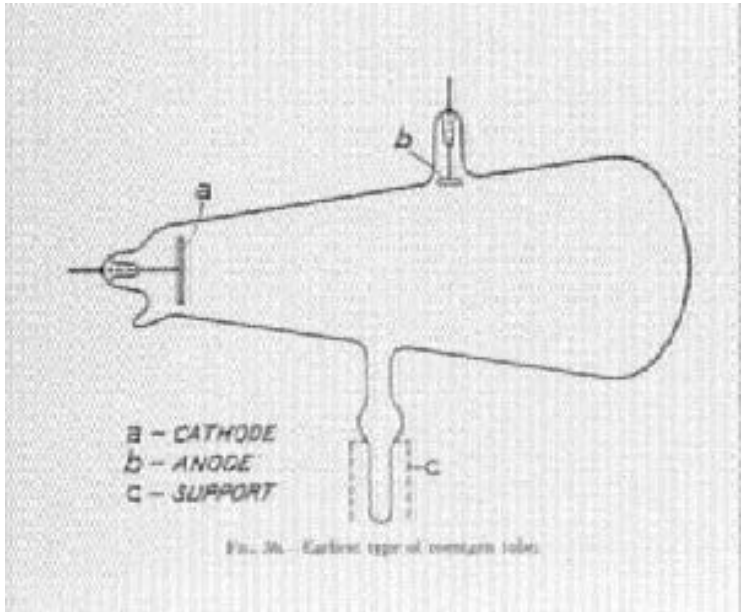
**William Roentgen**
**German Physicist - 1895**

- Was working with cathode ray tubes when he noticed that a phosphorescent material in his lab was glowing several meters away.
- He made a phosphorescent screen and was shocked when he put his hand in front of the screen – he could see the outline of his bones!!
- He did not know what kind of rays were responsible for this phenomenon so he called them *X-rays*



Roentgen's Wurzburg Laboratory





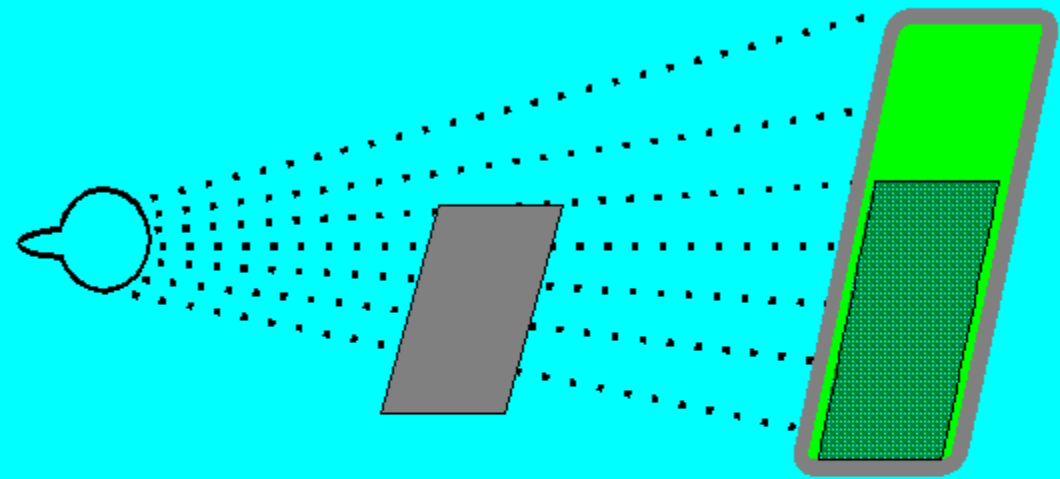

Crooke's Tube Similar to That Used in Roentgen's Discovery of X-rays

Cathode ray tubes were known to glow when a current was passed between the cathode and anode. Röntgen shielded his tube with black cardboard to darken the room. This is probably because he was either interested in observing faint fluorescence in materials such as barium platino cyanide or interested in the laws of absorption of "cathdode rays“. Cahthode rays (electrons) were easily absorbed by the walls of the glass enclosure and air. So the glow would be faint.

By the end of the year 1895, Röntgen discovered many properties of his X-rays.

- They traveled in a straight line from the point that the cathode rays in the tube struck the glass wall of the tube.
- They were exponentially absorbed by matter but very much less so than cathode rays.
- They possessed photographic properties.

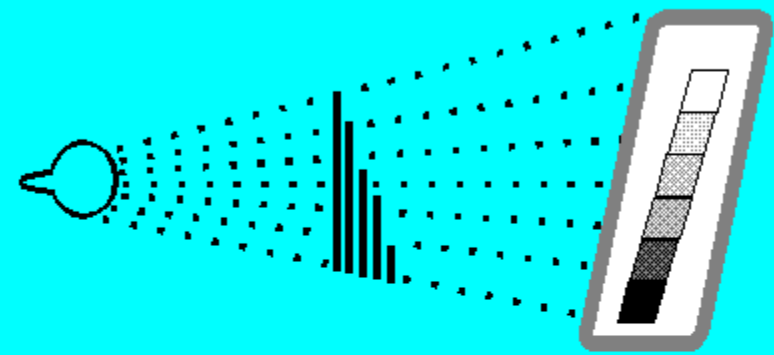
# TRANSPARENCY OF MATERIALS



*Fluorescence still may be clearly detected behind plates of copper, silver, lead, gold, or platinum, but only if the plates are not too thick.*

*Roentgen*

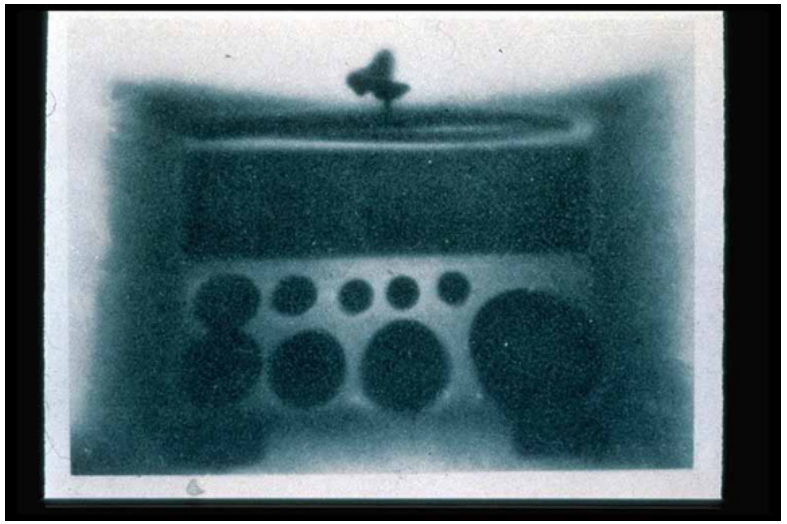
# EFFECT OF THICKNESS ON TRANSPARENCY



*As the thickness increases all materials become less transparent. In order to find a possible relationship ...I made photographs in which the plate was partly covered with ... layers of tinfoil in a steplike arrangement...*

*Roentgen*

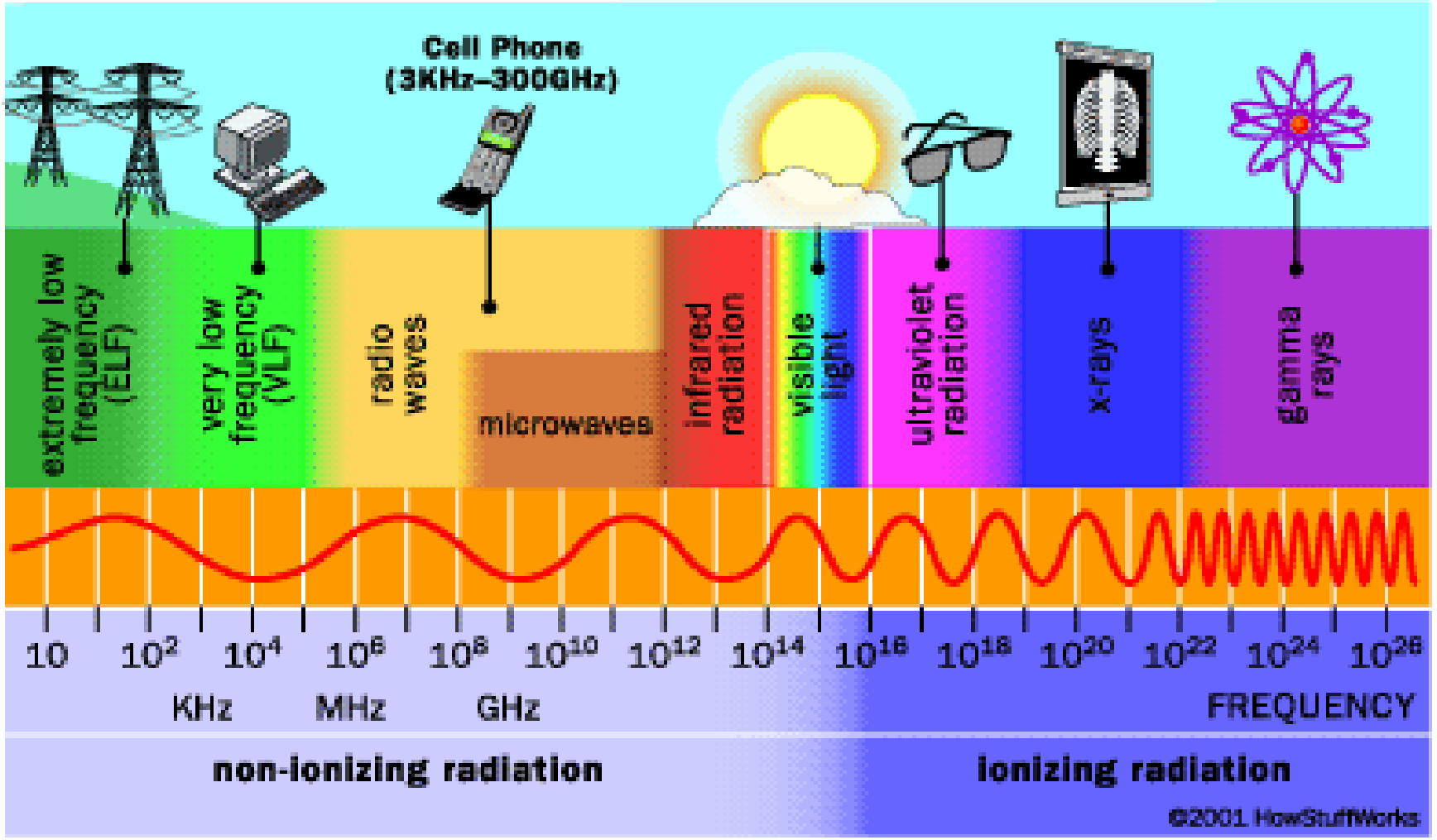
Using the photographic property, he was able to produce photo's of brass weights in a wooden box and, soon thereafter, the first photo of the bones in a living hand (his wife’s).  He also discovered that the output of x-rays could be increased by impinging the cathode rays on a heavy metal "anticathode" which could also be the anode of the tube.  This arrangement is today the basis of the modern x-ray tube.



# Electromagnetic Spectrum (of waves)

- (x-rays were part of EM spectrum)
- Light, heat (infra-red), microwaves, ultra-violet, x-rays, gamma rays and radio waves are all just energy waves of different frequencies.
- The sun emits radiation across the EM spectrum

# Electromagnetic Spectrum




Low Frequency
Low Energy

High Frequency
High Energy

# Summary of EM radiation

- **All** EM radiation travels at the speed of light ($3.0X10^8$ m/s)
- Frequency is proportional to Energy

$$f \propto E$$

- Frequency is inversely proportional to wavelength

$$f \propto \frac{1}{\lambda}$$

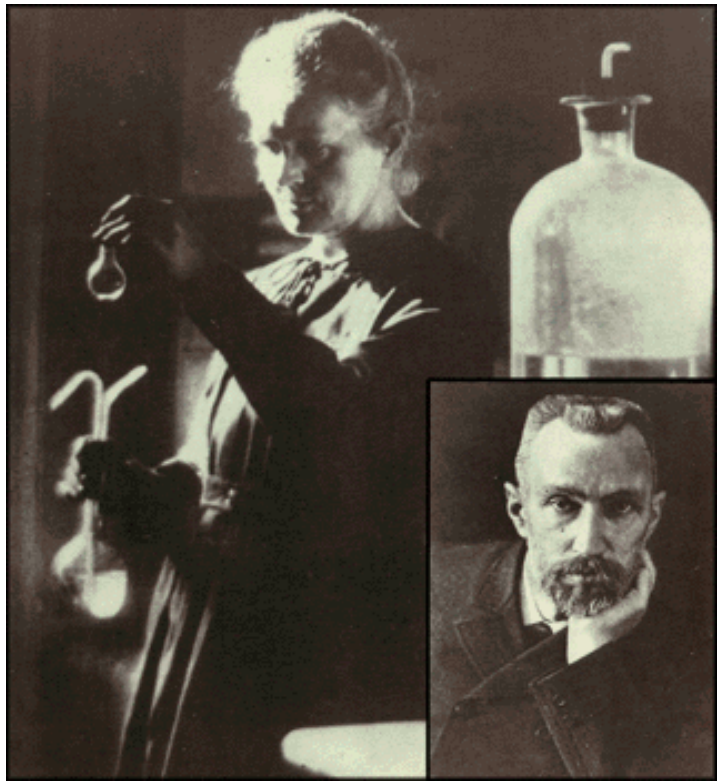
- EM radiation has NO MASS and can travel without particles

# Discovery of Radioactivity

Henri Becquerel
French Physicist

- Becquerel put different elements in the sun and then placed them on photographic plates in dark drawers to study phosphorescence.
- One day in 1896 there was no sun and he put Uranium on a photographic plate in a dark drawer.  The next day the plate was cloudy!  Energy was coming from Uranium itself!

# Discovery of Radium and Polonium



Marie and Pierre Curie of Poland and France

- Marie and Pierre Curie spent years purifying radioactive elements.
- They discovered new radioactive elements Radium and Polonium in1898.