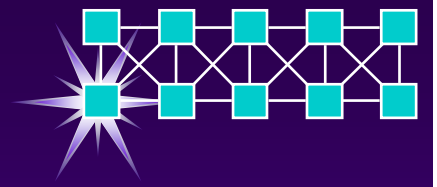
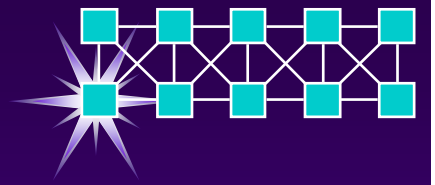


# *Principles of Medical Imaging Systems*

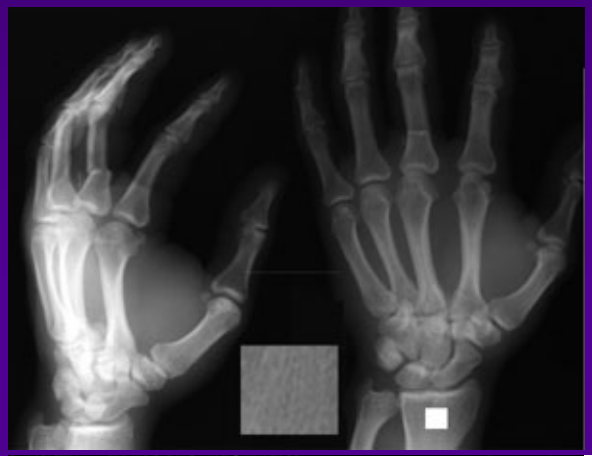
Hyongsuk Kim

- Chonbuk National University, Korea
- Visiting Scholar, UC Berkeley

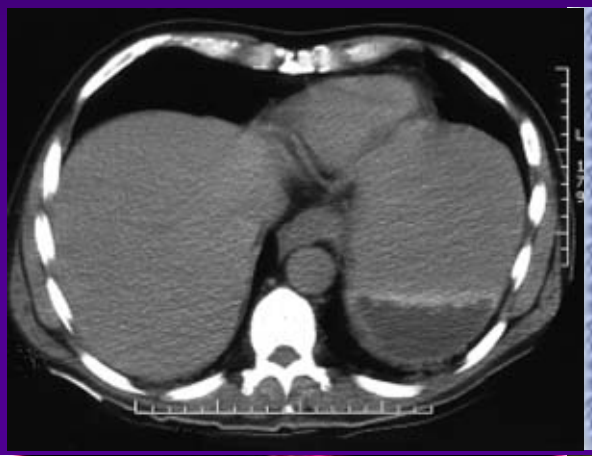
# *Examples of Medical Images*



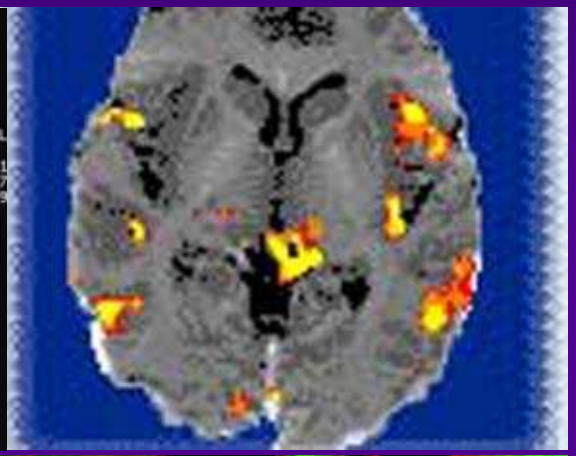
**X-Ray**

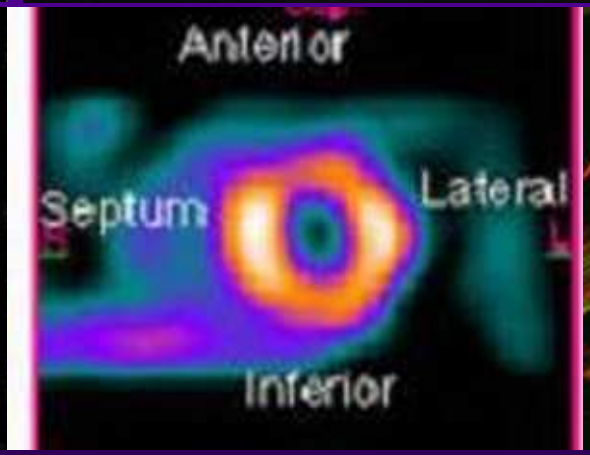


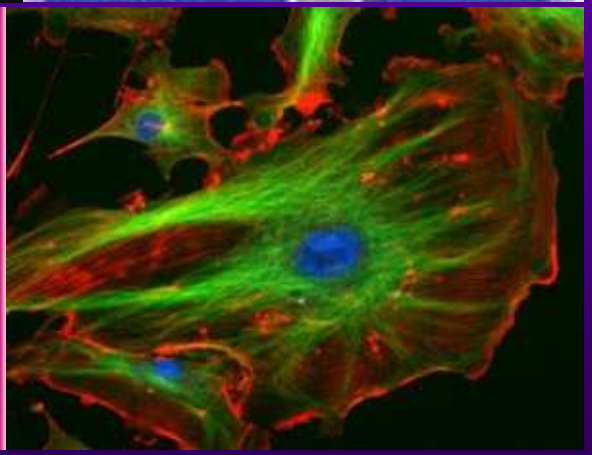
**CT**



**fMRI**

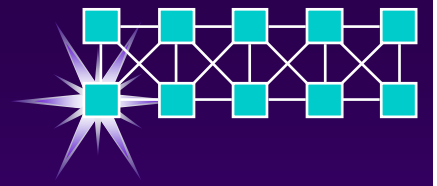


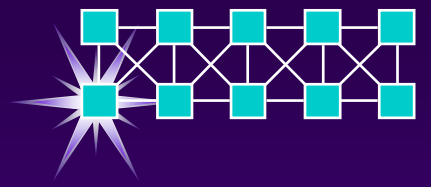
**Ultrasound** **PET** **SPECT**

# *Medical Imaging Systems to be covered*



- Radiography
- Tomography
- Magnetic Resonance Imaging (MRI)
- Nuclear Medicine
- Ultrasound
- Electrical Impedance Tomography
- Breast Thermography
- Others (**Elastography, Spectroscopy, Ophthalmology**)

# *Radiography*



- First imaging technique available in modern medicine (medical imaging=radiology, radiologist)

- Two forms of radiographic images are in use in medical imaging
  - projection radiography (X-Ray)
  - fluoroscopy (Continuous X-Ray)

# *The discovery of x-rays*

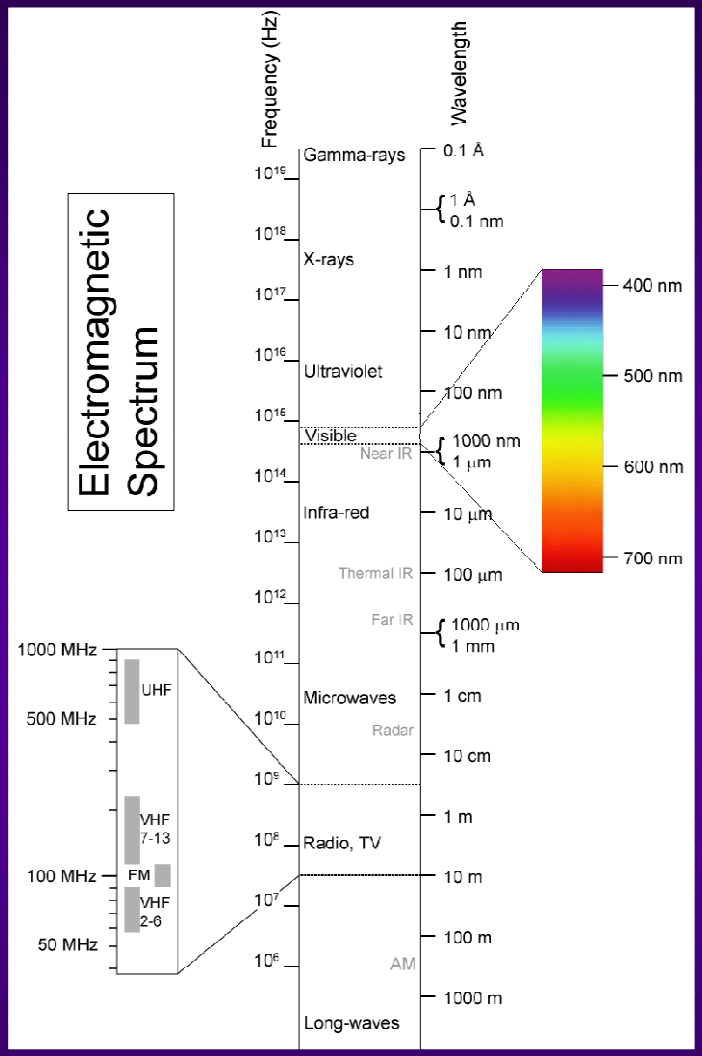
*physics, technology and medicine*

**C. W. Roentgen (around 1885)**
**graduated from**
- **University of Zurich**
- **Diploma Swiss Fed. Institute**


**First X-ray:**
**hand of Emma Roentgen**

# *Projectional radiographs*

- Commonly known as x-rays
- Often used to determine the type and extent of a fracture
- With the use of a contrast media, such as barium, they can visualize the structure of the stomach and intestines




**X-rays are part of the [electromagnetic spectrum](#).**

# *X-Ray tube*

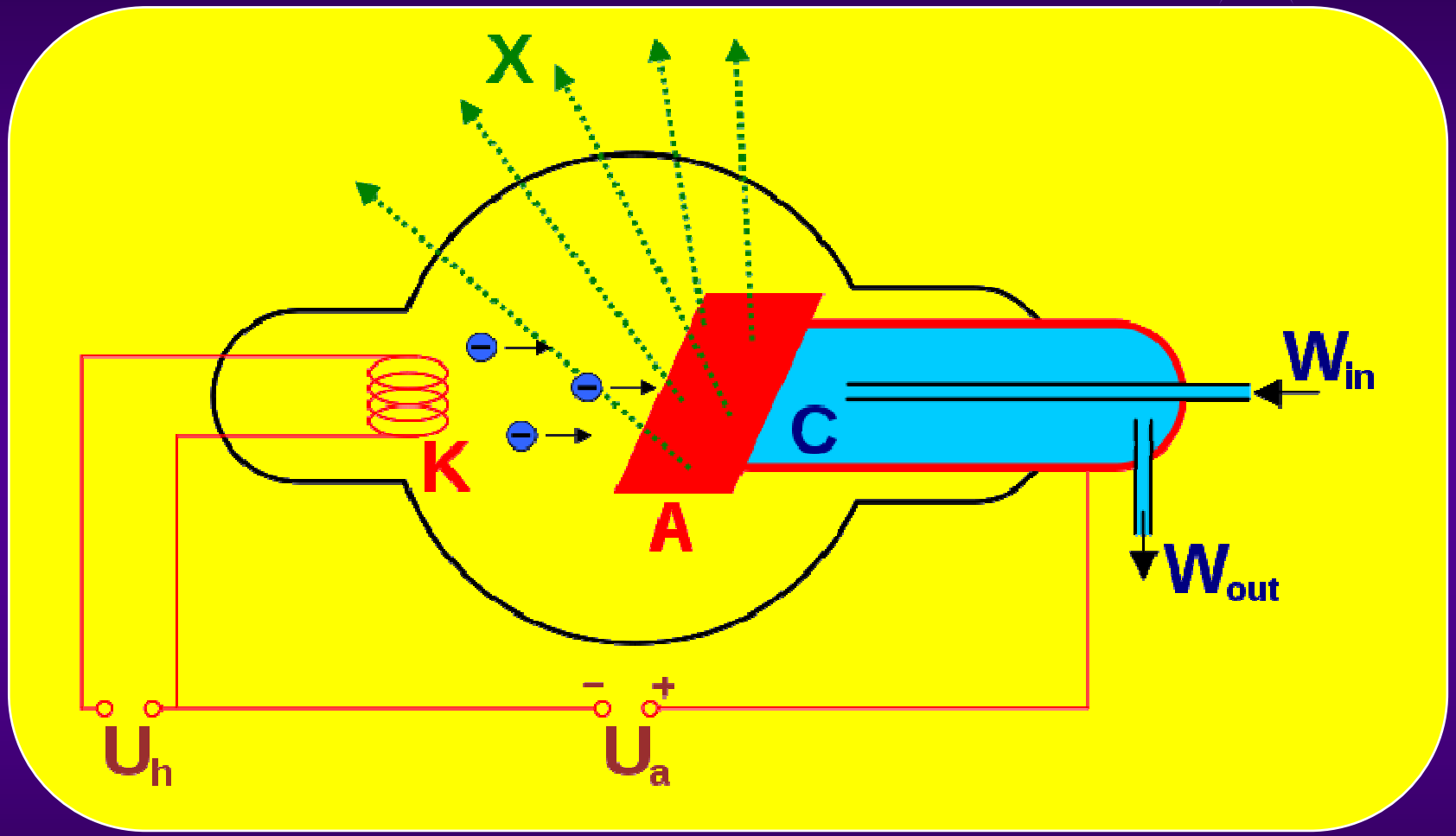
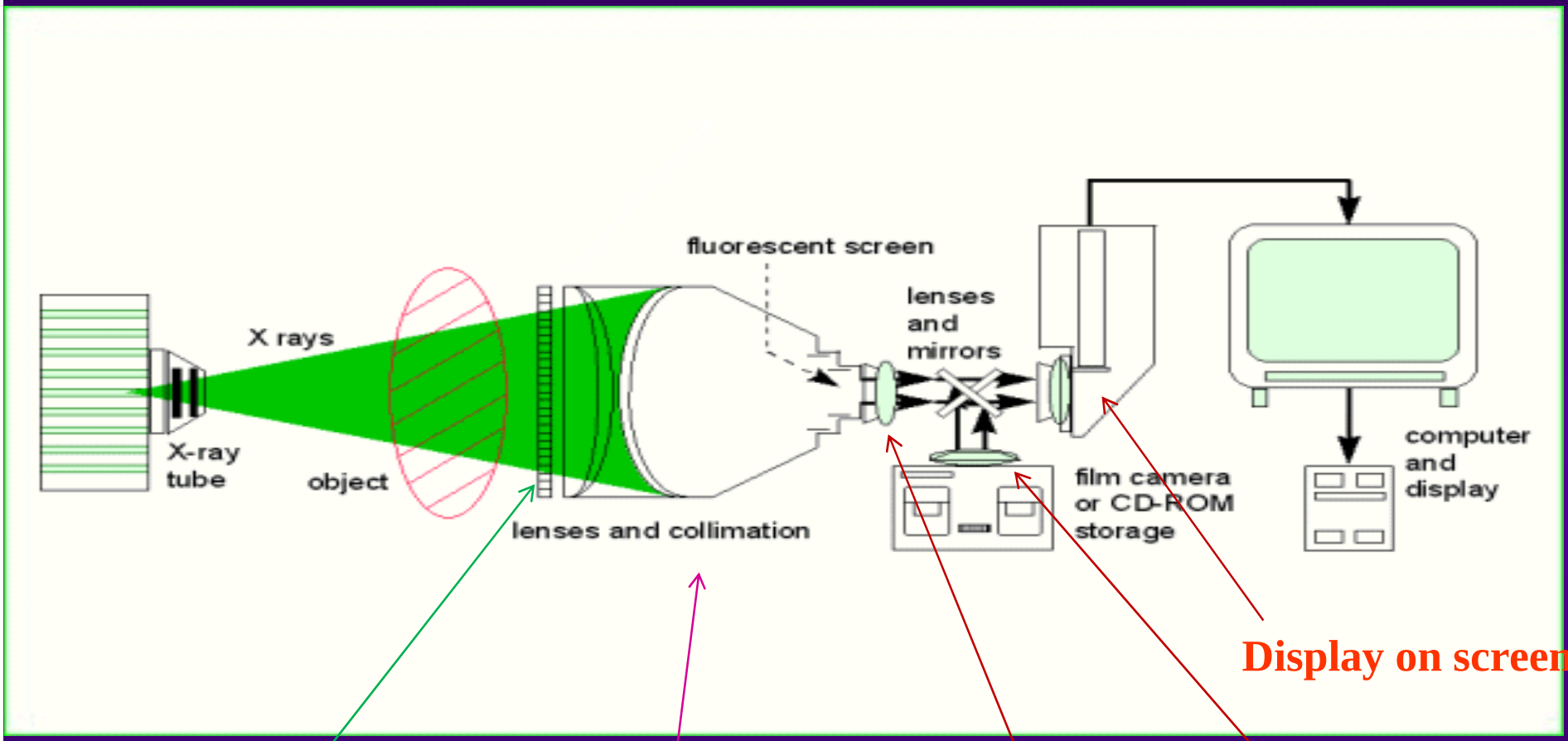



**Diagram of a water cooled X-ray tube (simplified/outdated)**

- Electrons are accelerated in vacuum from the cathode to the anode.
- Most of the electron energy will produce heat at the anode. Some percentage will be converted to X-ray.
- Emission occurs when filament is heated by passing current through it.

# X-Ray system




Converted to electrons (Scintillators)

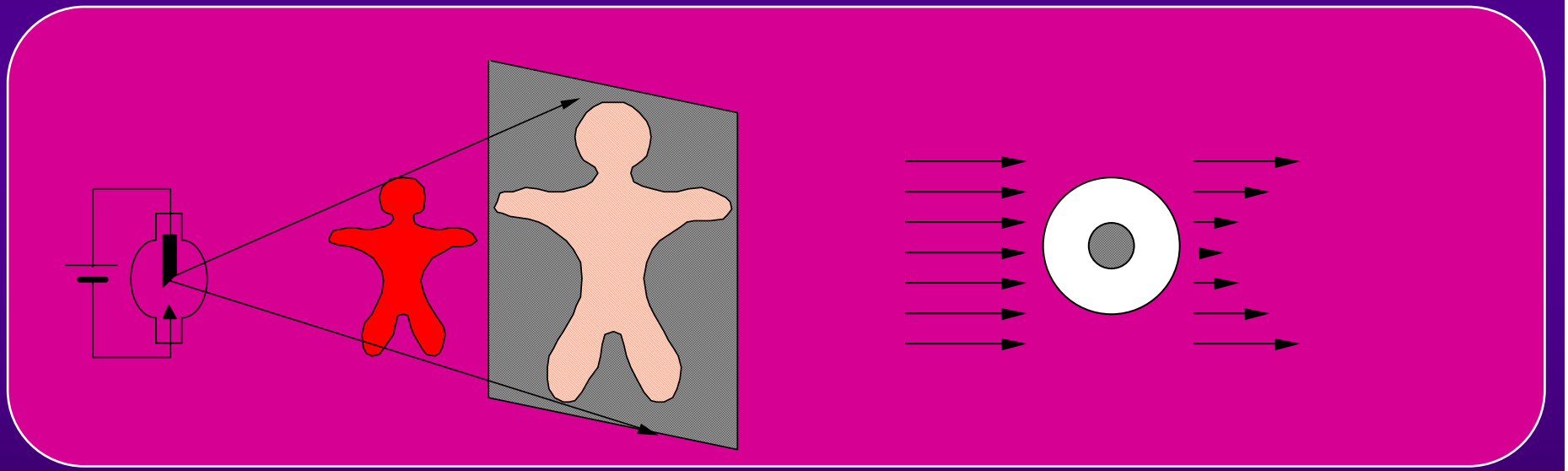
intensified (acceleration)

Shown on Smaller fluorescent screen

Recorded in film

Display on screen

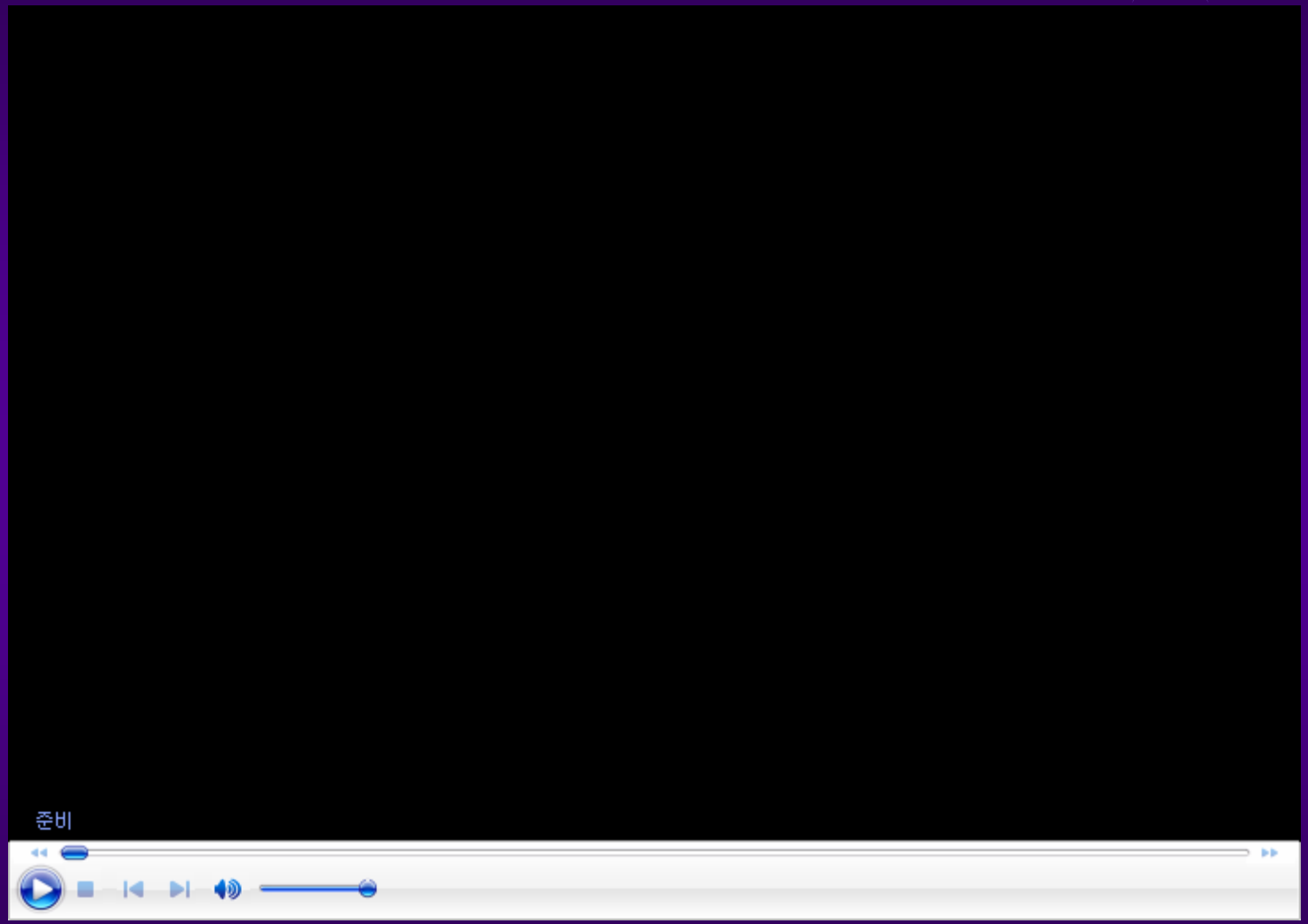
# *X-ray Imaging: How it works.*



X-ray shadow cast by an object

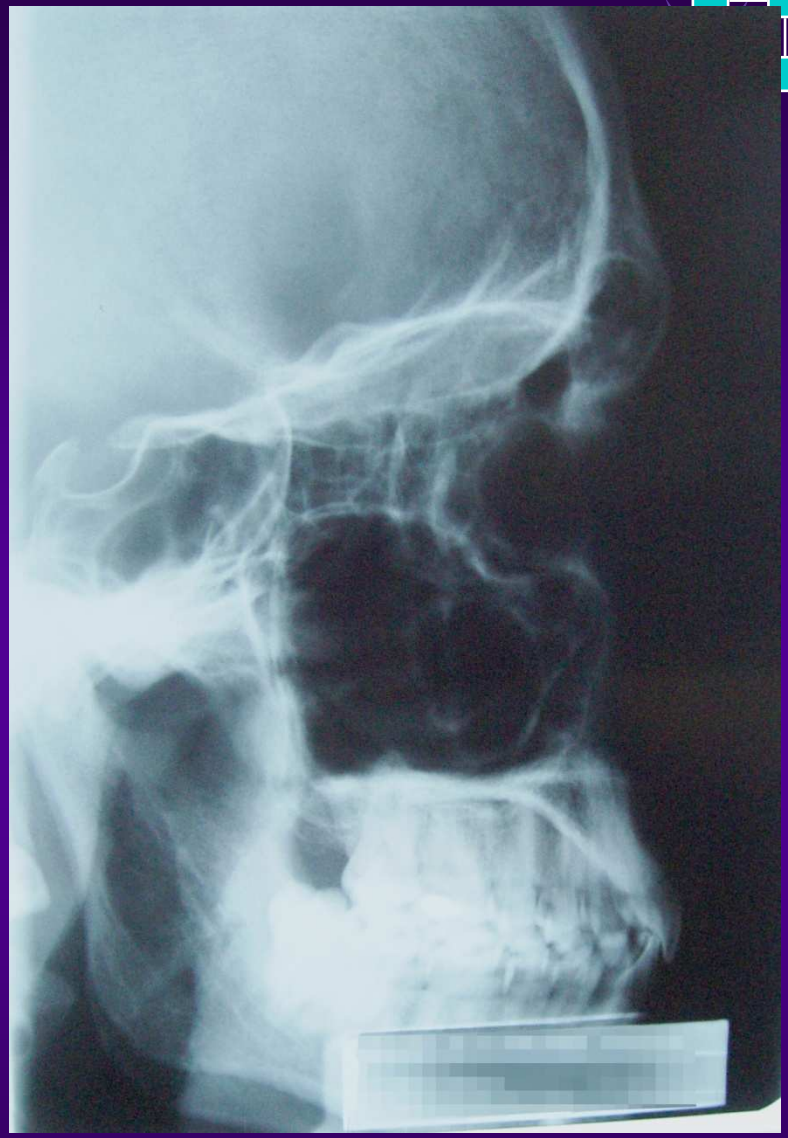
**Strength of shadow depends on composition and thickness.**

# X-Ray Projection and enlargement



# Applications of X-Ray

*Medical Application*



X-ray image of the paranasal sinuses, lateral projection

## *Security Application*

**Used at Airport**
**to detect**
**non-metallic devices and objects as well as weapons**

# Application to Inspections

**Brad Byers insisted he could sallow swords.**
**X-Ray image proves it.**

# *Imaging principle of Radiography*

- X-rays are a form of ionizing radiation, meaning it has sufficient energy to potentially remove electrons from an atom.

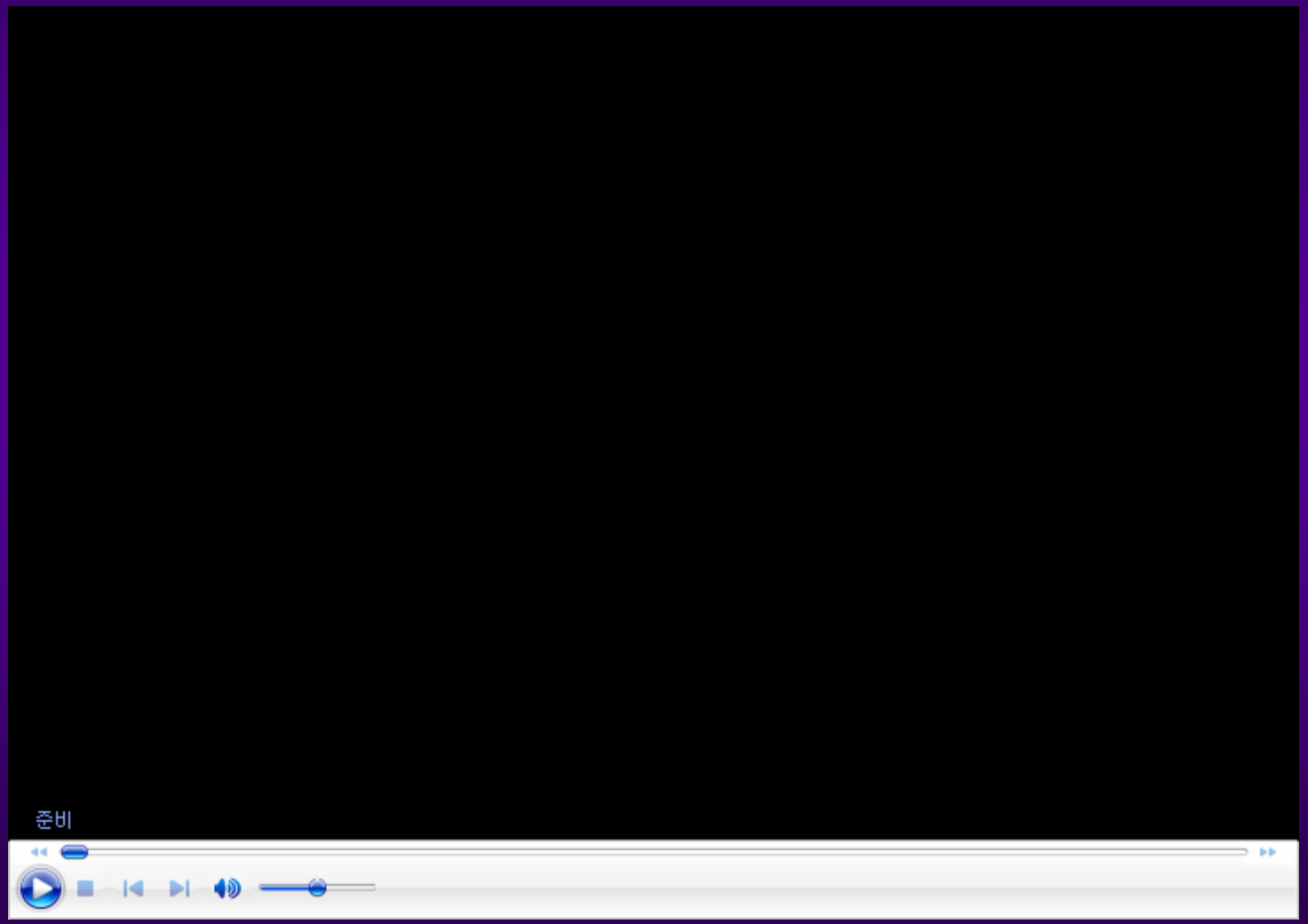
- When the primary beam passes through the body, some of the radiation is absorbed in a process known as attenuation.

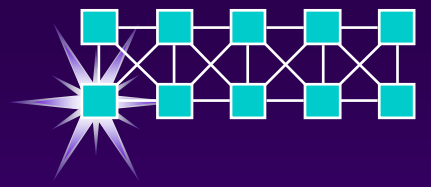
- Denser anatomy has a higher rate of attenuation,

  so bone will absorb more x-rays than soft tissue.

- Areas with more heavily exposed will be processed as being darker.

# Xray Planar Waves
# Intensity varies due to the absorption depending on the density of tissues

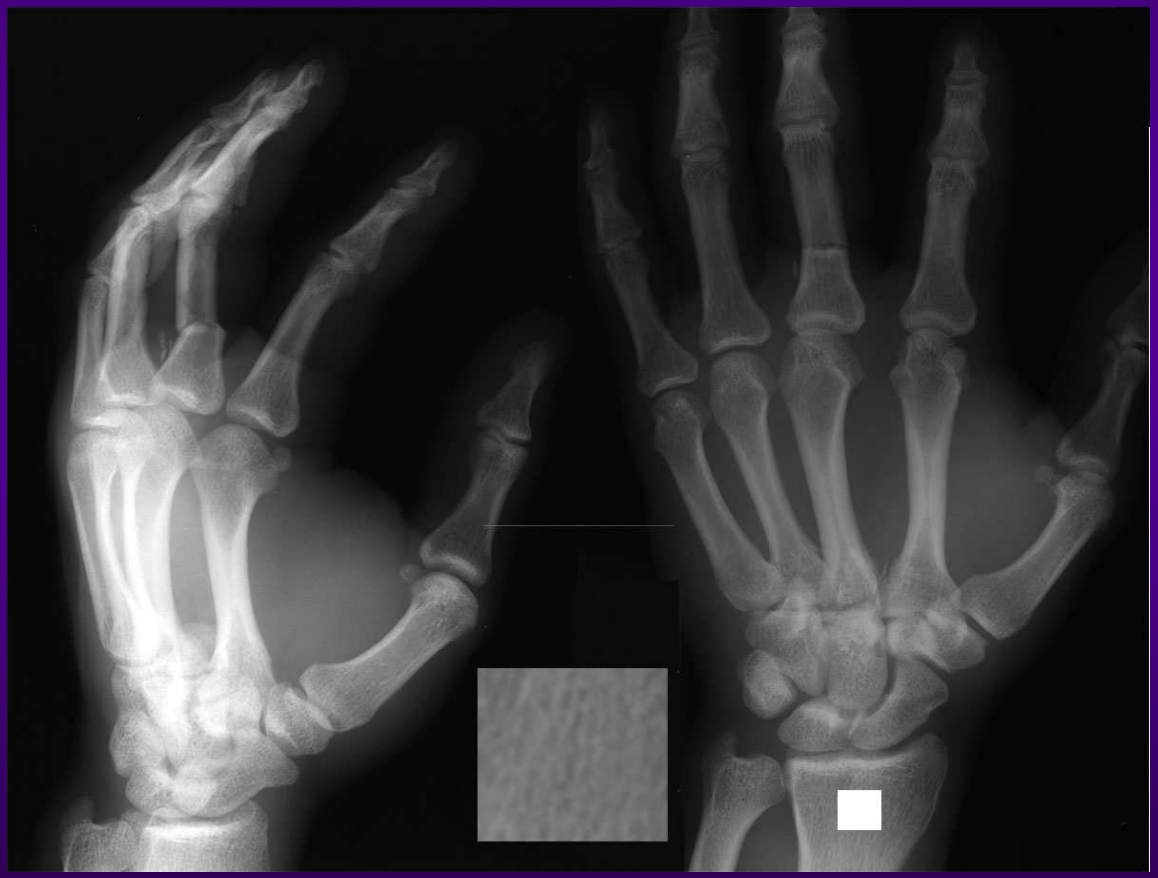


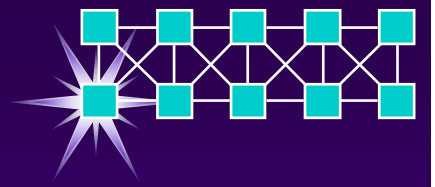


- The remnant beam "shadow" may be converted to light using a fluorescent screen
- then, captured on photographic film
- and/or captured by a phosphor screen to be "read" later by a laser (CR), or CCD camera.

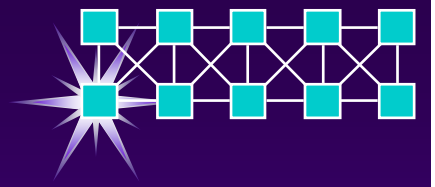
- Relatively low-cost investigation with a high diagnostic yield.

# *X-ray Image of Hand*





Uses X-rays in different amounts and strengths depending on the body part to be imaged



Soft tissues:

- less-penetrating X-ray beam is used.

u Tissues commonly imaged include

. the lungs

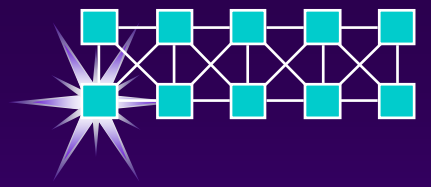
. heart shadow in a chest X-ray,

. air pattern of the bowel in abdominal X-rays

. soft tissues of the neck,

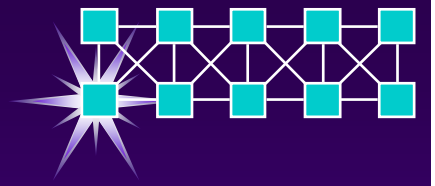
- Dental radiography uses a small radiation dose with high penetration to view teeth.

# *Density*

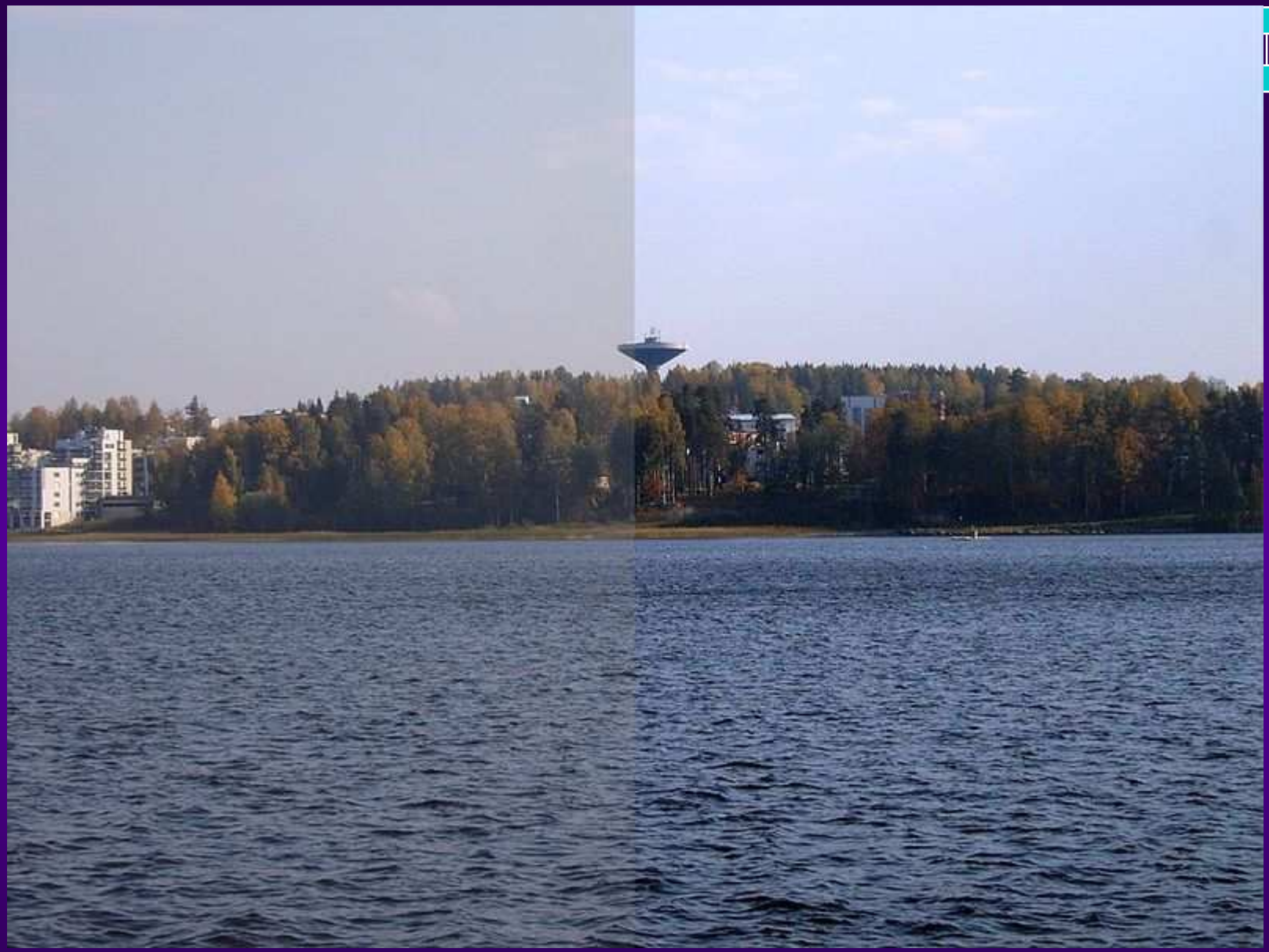


- A higher radiographic density:darker
  lower density: lighter

# *Contrast*



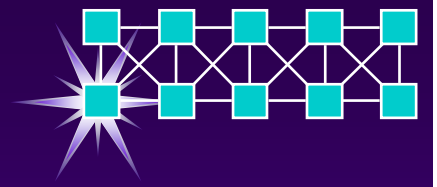
- Contrast is the range between black and white on the final radiograph.
- High contrast, or wide latitude, means there is much gray on the radiograph, and there are many steps between black and white.



**Left side of the image has low contrast, the right has higher contrast.**

**Changes in the amount of contrast in a photo**

# *Traditional radiography with X-Ray Film, Direct radiography*

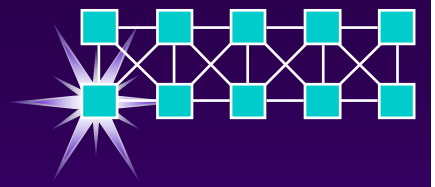


- Create an image directly on a photographic film.

- The film is covered by a photographic emulsion, which consists of a layer of gelatine containing tiny silver bromide crystals.

- The emulsion is sensitive to photons having a wide range of energies; X-rays, ultraviolet radiation, and visible light

- The silver bromide crystals are ionised by the photon energy.



- When the film is developed, black metallic silver is precipitated from those crystals containing silver ions.

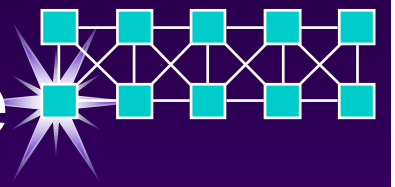
  (The non-ionised silver bromide crystals remain unchanged and invisible.)

- After being developed, the film is washed, fixed, and dried.

X-Ray of a pregnant woman

**X-ray instrument for direct radiography**

# Radiographic cassette
**(direct radiography)**

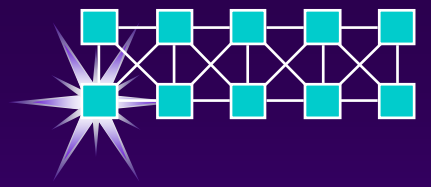


- 10-1,000 times as effective as film alone, allows a considerable reduction in radiation dose.
- Protects the film from external light
- Contain a grid to reduce secondary or scattered radiation to the film,

- (Most popularly ) Direct radiography using radiographic cassettes is still quantitatively the most important radiological modality.

- (Higher resolution) The highest spatial resolution

# *Fluoroscopy*



- Produces a constant input of x-rays, at a lower dose rate.

- Contrast media, such as barium, iodine, and air are used to visualize internal organs as they work.

Fluoroscopic Room

**Fluoroscopic assisted injection**

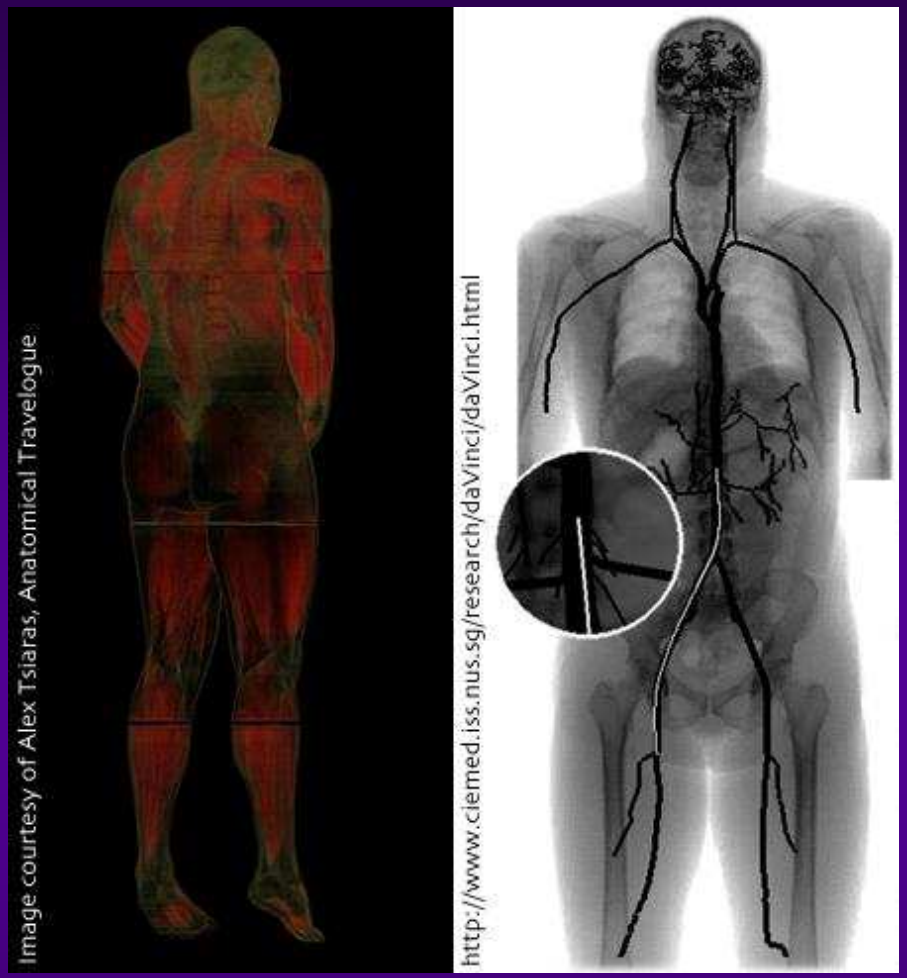
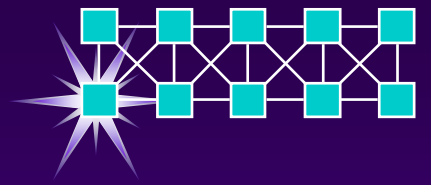



**Figure : (a) Interactive volume rendering using 3D texture mapping; and (b) Fluoroscopic view (using CT data) with vasculature and catheter highlighted.**

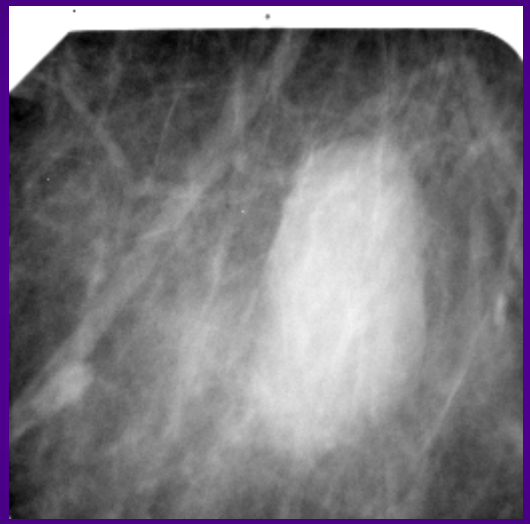


# *Mammography*

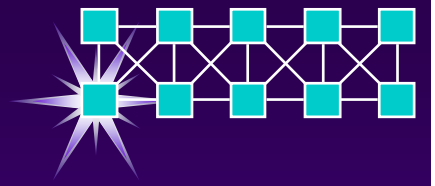
**: X-ray examination of breasts and other soft tissues.**

- The radiation used for mammography tends to has a lower photon energy than that used for the harder tissues.

- A reduced region of interest such as a tumor, a calcification or normal fibroglandular tissue are focused.
- The imaging system must have a sufficient spatial resolution so that structural detail small as 50 μm must be resolved adequately.
- The lowest radiation dose compatible with excellent image quality is need to be used.



**Benign lesion - Fibroadenoma**



◆ Mammography is used to detect a number of abnormalities, the two main ones:

calcifications and masses.

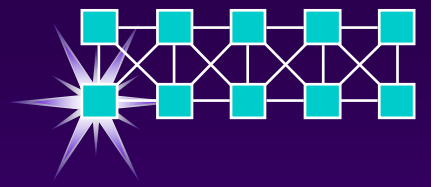
◆ Calcifications: tiny mineral deposits within the breast tissue that appear as small white spots on the films.

- macrocalcifications and
- microcalcifications.

- **Macrocalcifications :**
  - **Coarse (larger) calcium deposits**

  - **Macrocalcification deposits are associated with benign (noncancerous) onditions and do not require a biopsy.**

- **Microcalcifications:**
  - **tiny (less than 1/50 of an inch) specks of calcium in the breast.**
  - **Referred to as a cluster and may indicate a small cancer.**



## Masses:

- A mass is any group of cells clustered together more densely than the surrounding tissue.

- Masses can be caused by benign breast conditions or by breast cancer.