Biomedical Engineering

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- **의용-생체 영상**
  Bio-Medical Imaging

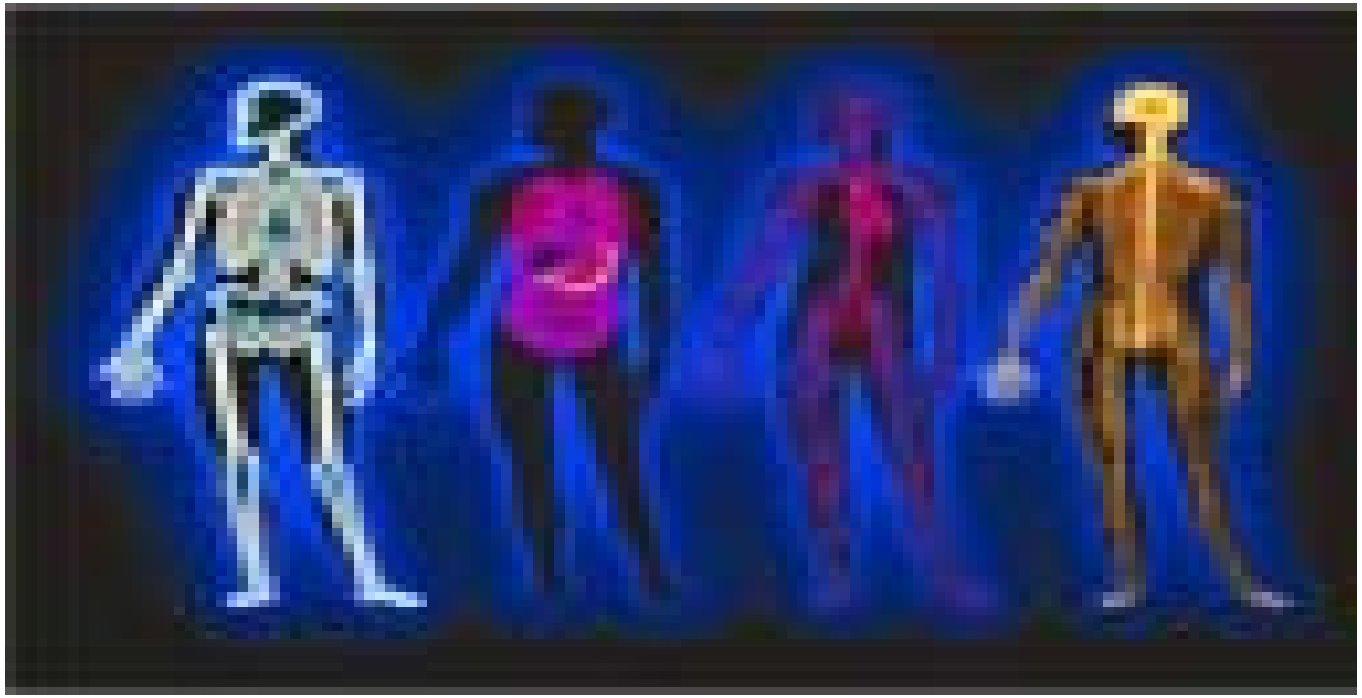
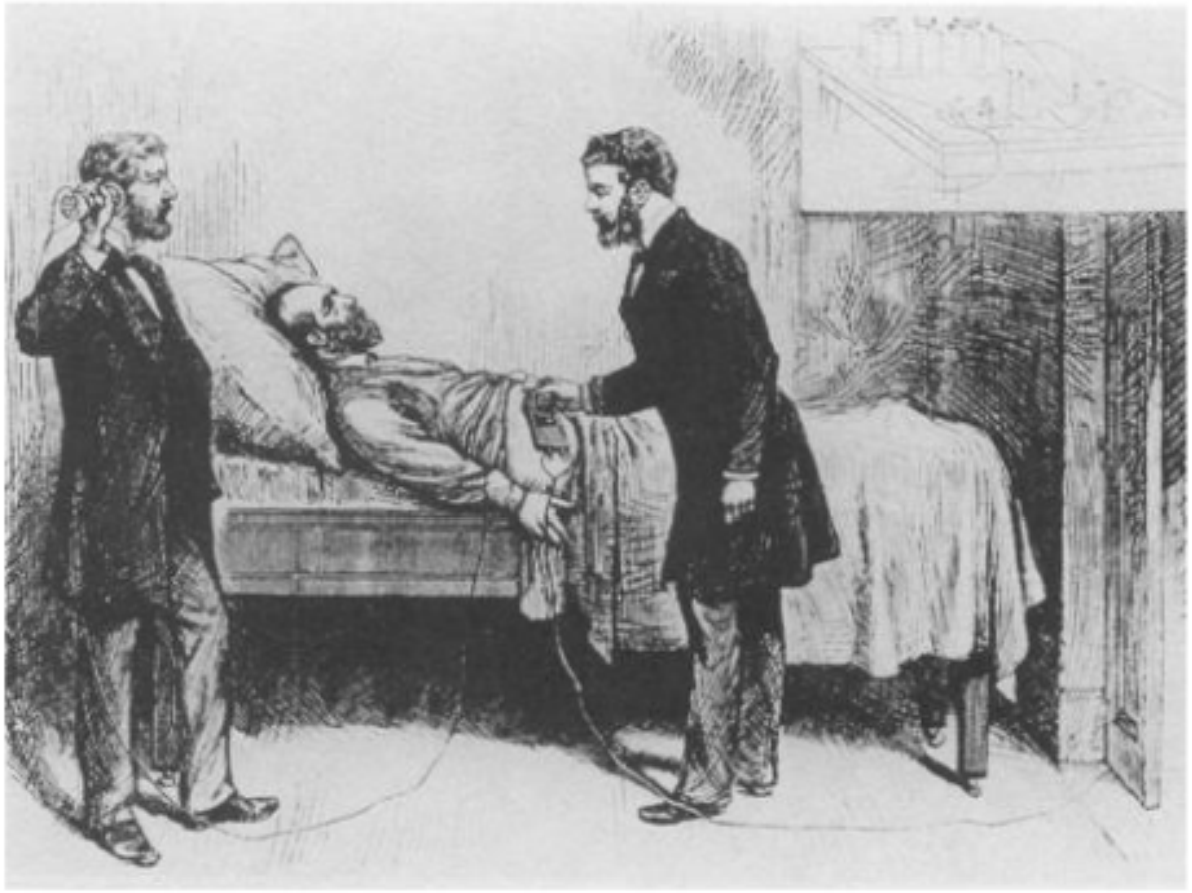
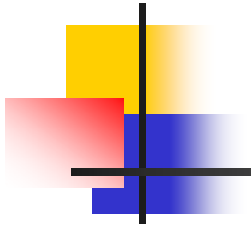



Image credit: Space Imaging North America-ISIS
Image date: 7 January 2005
"Seeing is Believing"
Reactor cooling tower, with steam plume
Reactor cooling tower, no steam plume
Image Credit: DigitalGlobe-ISIS
Image Date: 7 April 2005

Listening is Believing ??



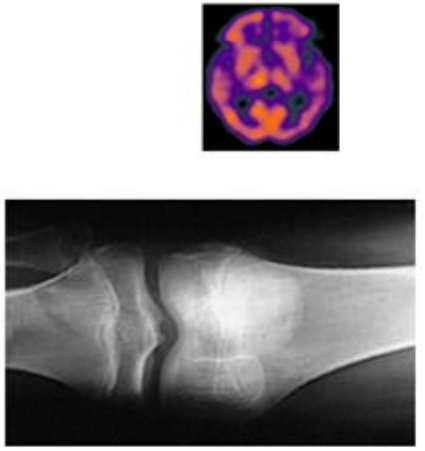


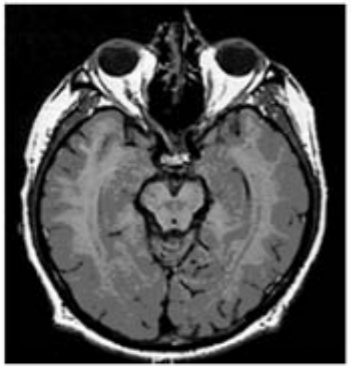
Bio-Medical Image

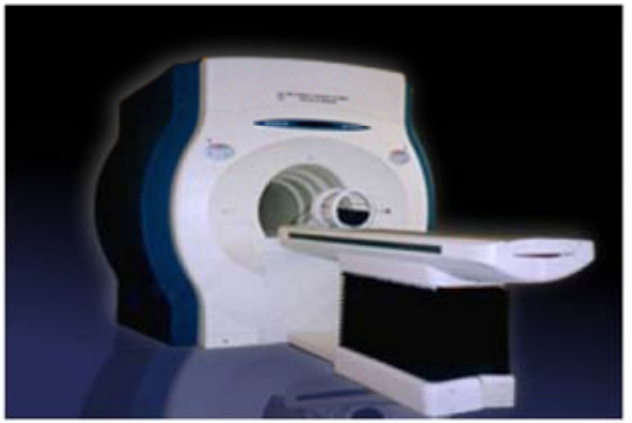
- 최근의 컴퓨터의 의학에로의 이용이 활발하여 지면서 출현한 초음파, **X**선영상, **MRI**영상, 핵의학 영상및 현미경 영상 등의 의학분야의 영상에 대하여 새로운 영상 촬영방법, 처리 방법 및 분석 방법 등에 관하여 연구하는 분야이다
- 생체신호 처리의 경우와 달리, 취급하는 데이터가 **2**차원적, 때로는 **3**차원적이라는 특성이 있다

Bio-Medical Image

- 컴퓨터의 의학에의 이용 활발
- 초음파, X선영상, MRI영상,
- 핵의학 영상 및 현미경 영상 등
- 새로운 영상 촬영, 처리 및 분석 방법의 연구 및 개발
- 2차원적, 3차원적, 4차원적 신호







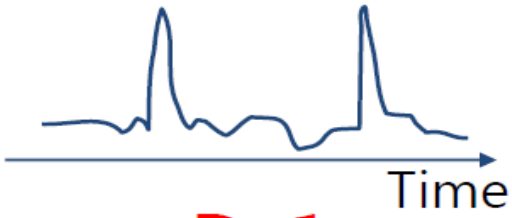
3.0 Tesla MRI form Medison

Image

Data in 2 dimension

Psys=120mmHg
Pdia=95mmHg
BW=80.5Kg
Height=179cm

D<1



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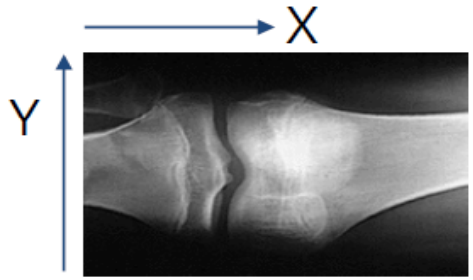

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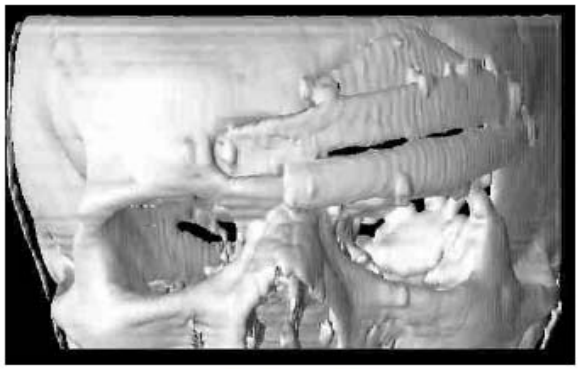

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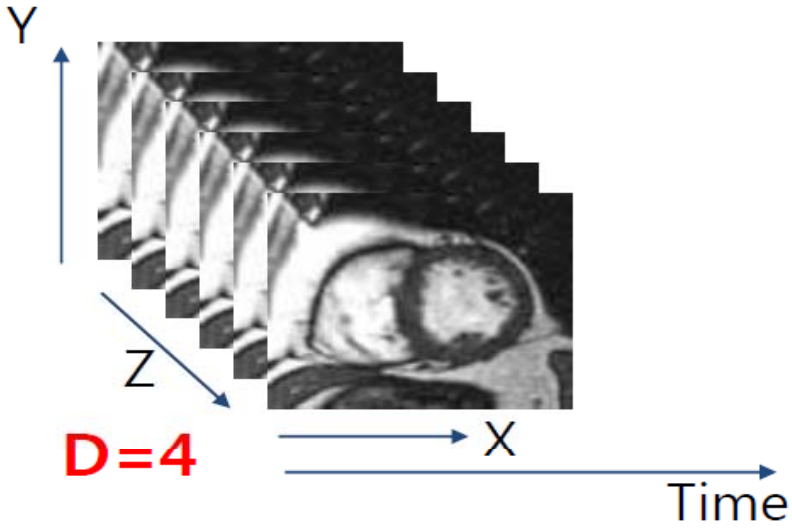
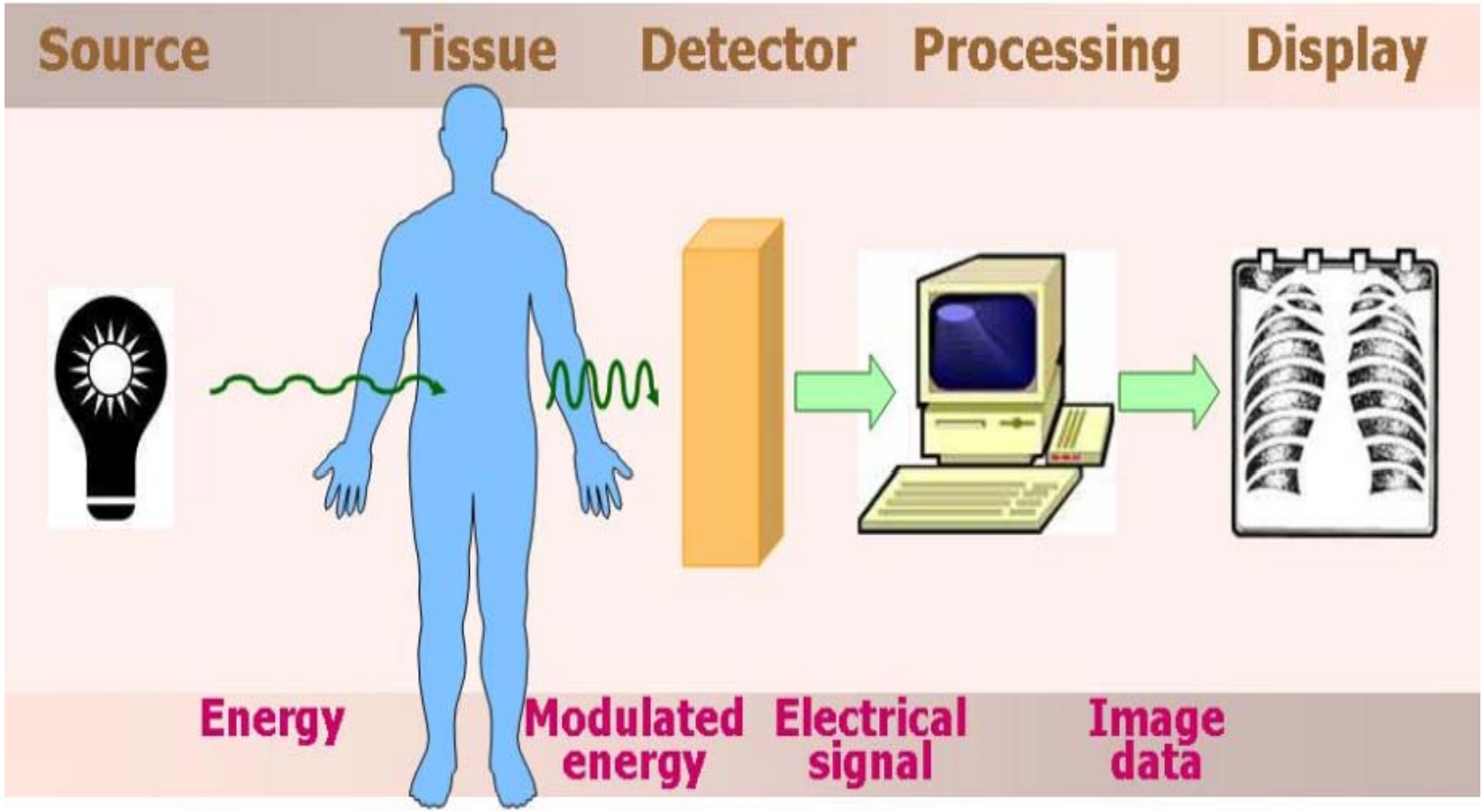


D=4

Human Body Imaging

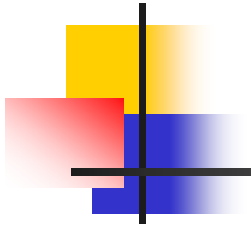
- Requires energy
  - **reflecting or penetrating** tissues
- Needs **interaction**
  - With atoms
    - Absorption, attenuation, scattering
  - With molecules: radioactive isotope
    - Metabolic, physiological
  - **Information** by interaction
- **Sensors** to detect modulated energy

Information Flow



What is Medical Imaging?

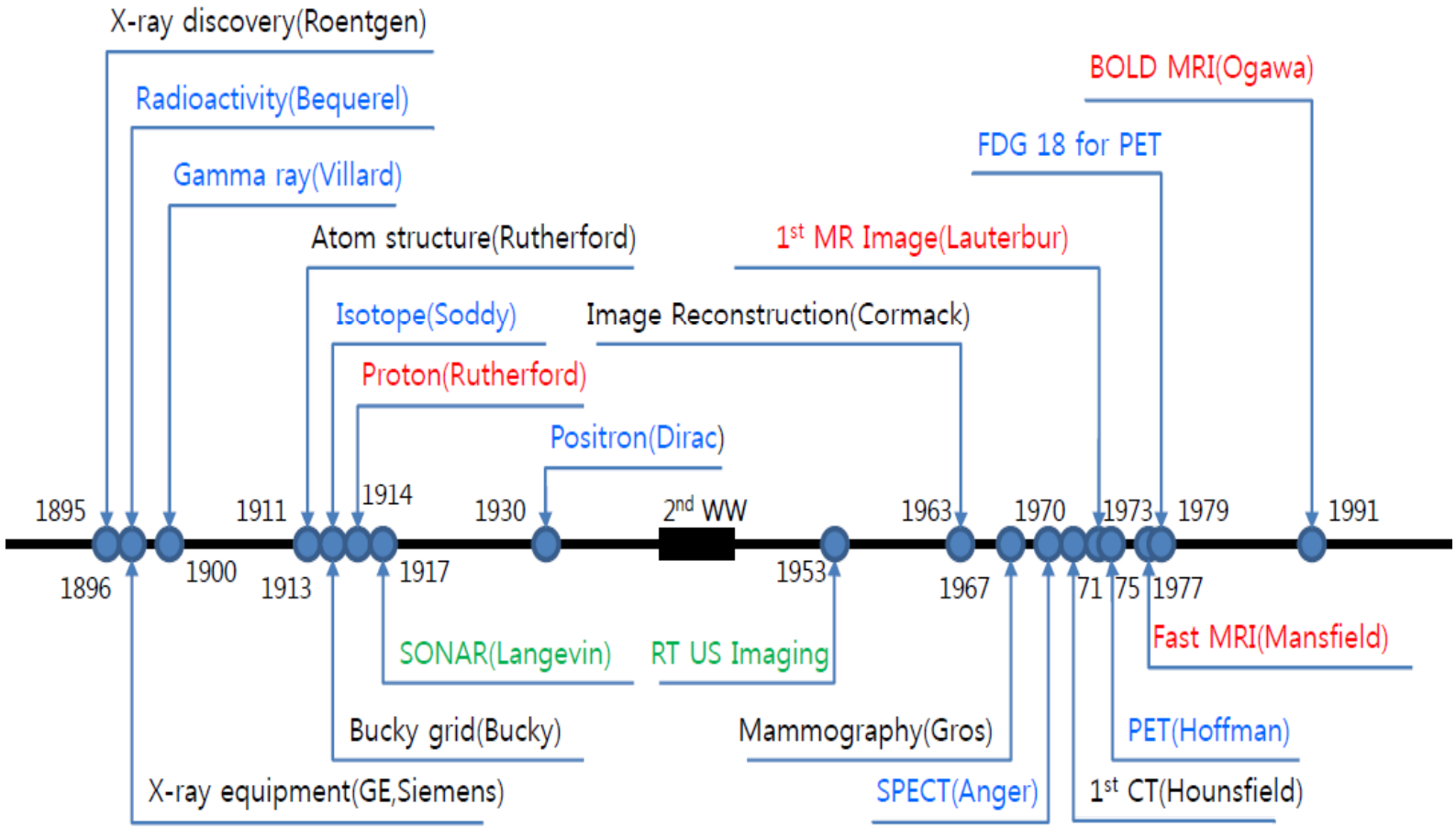
- Using an instrument to see the inside of a human body
  - Non-invasive
  - Some with exposure to small amount of radiation (X-ray, CT and nuclear medicine)
  - Some w/o (MRI and ultrasound)
- The properties imaged vary depending on the imaging modality
  - X-ray (projection or CT): attenuation coefficient to X-ray
  - Ultrasound: sound reflectivity
  - MRI: hydrogen proton density, spin relaxation.



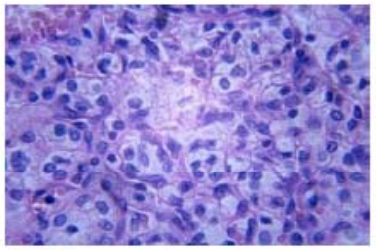
Medical Imaging

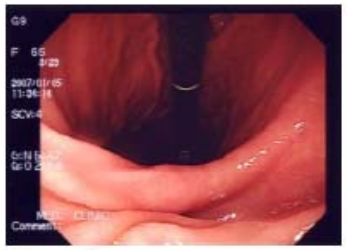
- **Concerns of Medical Imaging**
  - **Development of appropriate technologies**
    - ***To detect interaction*** **of all forms of radiation with tissue**
    - ***To extract clinically useful information*** **(displayed in an image format) from observations of this interaction**

Medical Imaging Timeline



Medical Imaging


Microscope


Endoscope

Visual Image

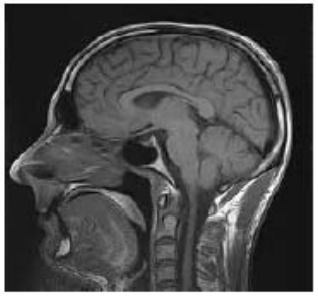

Ophthalmoscope

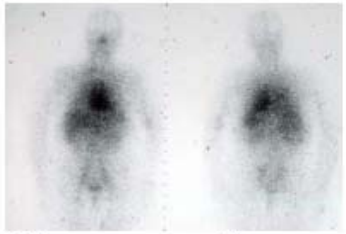
Radiography


Ultrasound

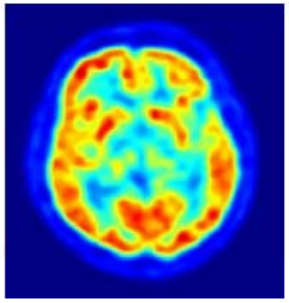

CT

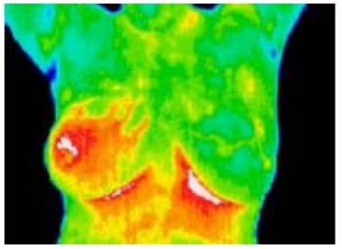
MRI




Gamma Camera


SPECT

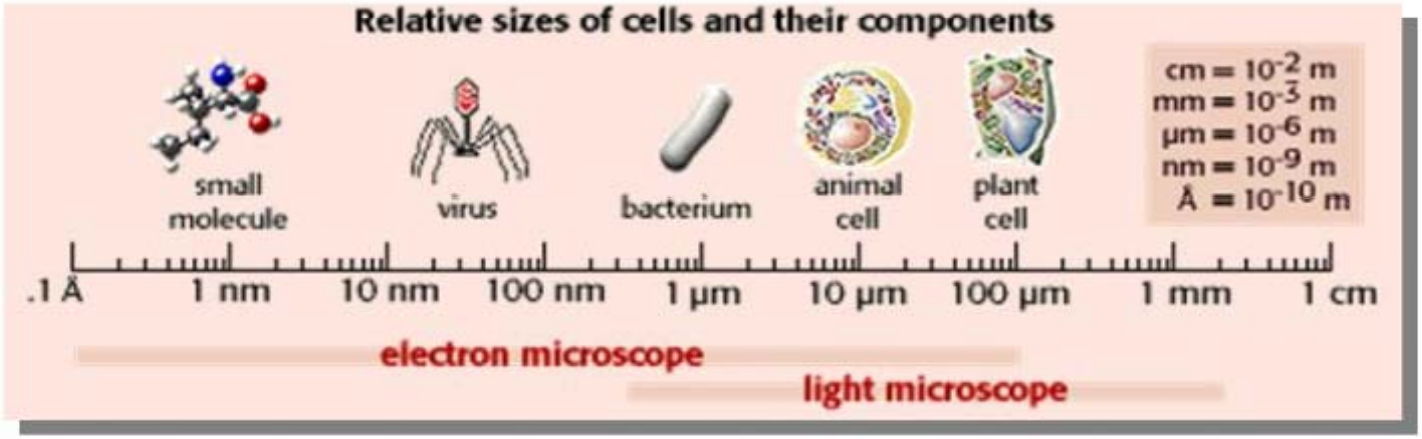

PET


Thermograph

Bio Imaging

"The key to every biological problem must finally be sought in the cell"

classical cell biologist, E.B. Wilson, in 1925



Classification: Energy

- **Electromagnetic wave**
  - RF
  - IR
  - Visible

  } Nonionizing Radiation

  - X-ray
  - γ-ray

  } Ionizing Radiation
- **Sound wave**
  - Ultrasound

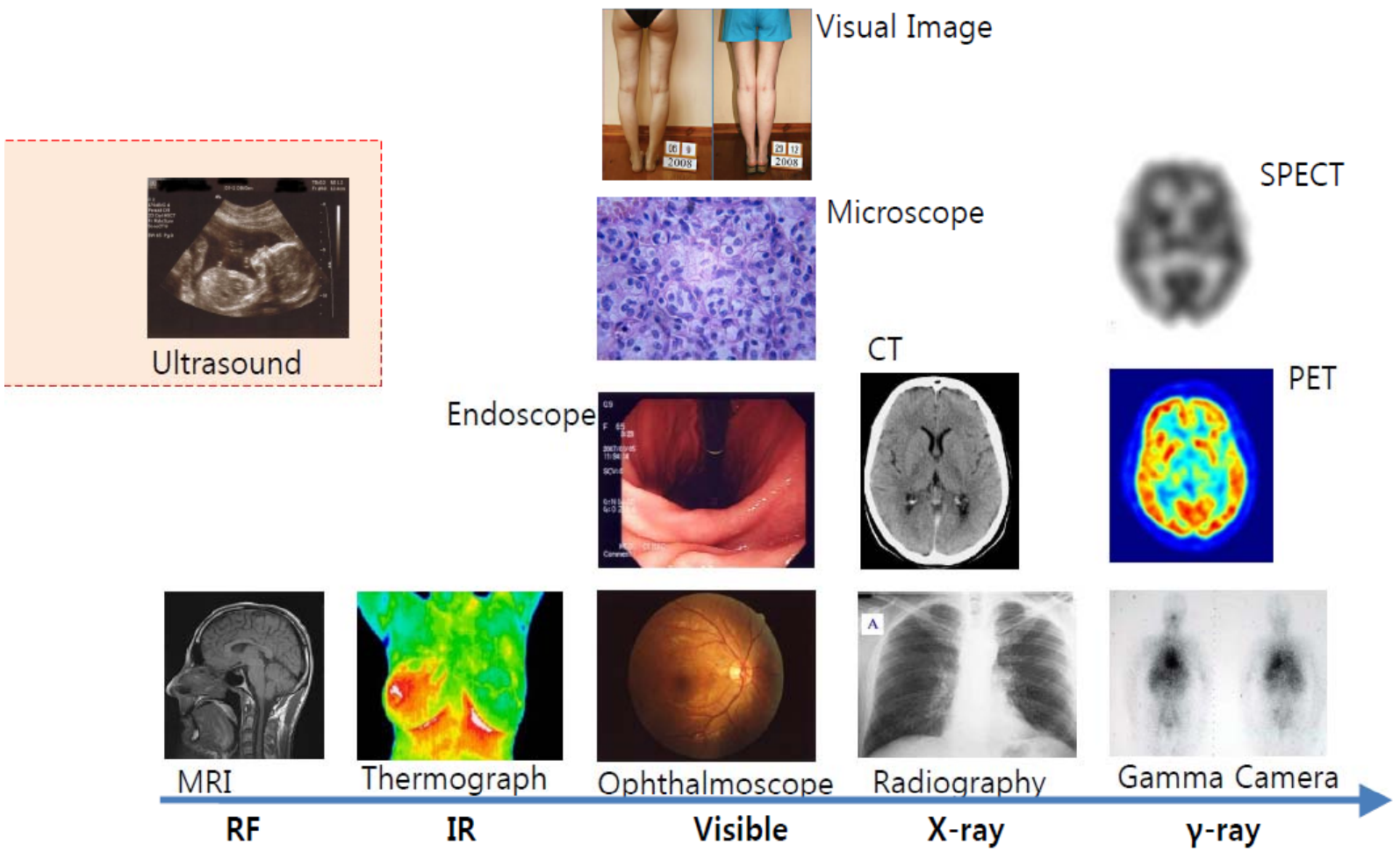
Classification: Modality

- Energy for Medical Imaging

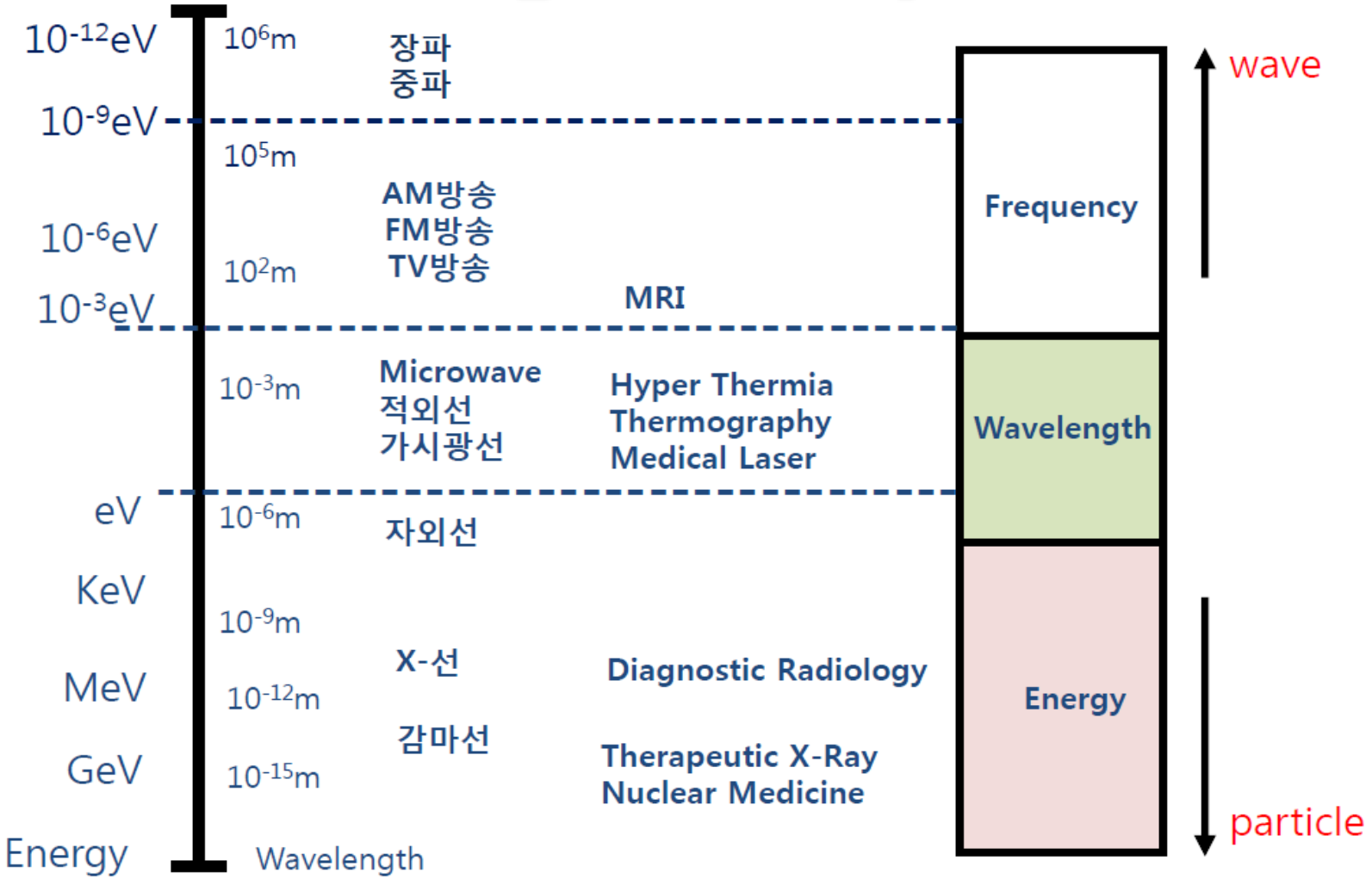
- **Visible light:** Visible observation
  - Skin photography, endoscopy, microscopy
- **X-ray:** Radiography
  - Fluoroscopy, mammography, CT
- **γ-ray:** Gamma Camera, SPECT, PET
- **Radiofrequency:** MRI
- **Sound:** Ultrasound Imaging
- **Infrared:** Thermography

Modality: different modes of making images

Modality by Energy

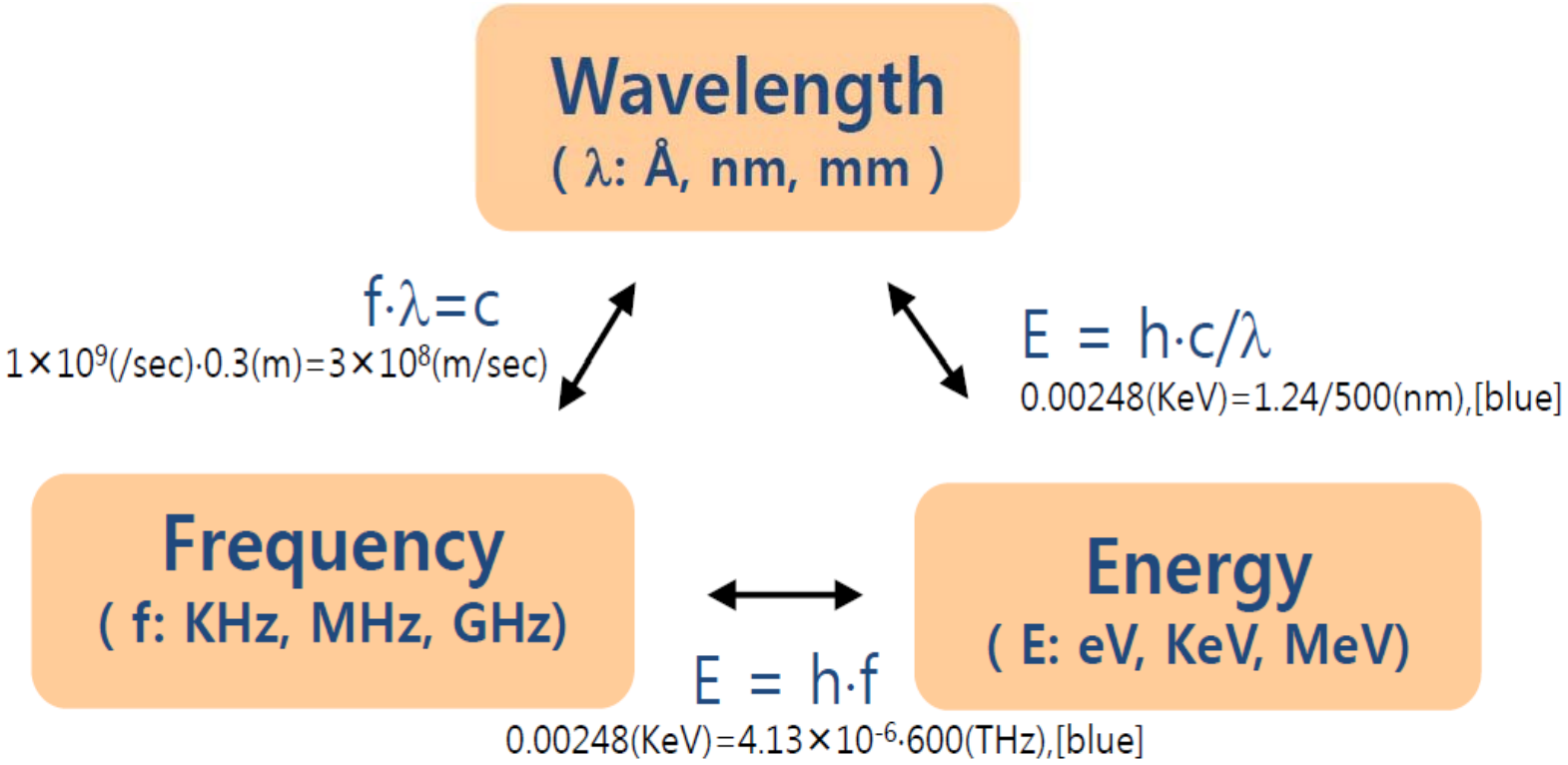


ElectroMagnetic Spectrum



ElectroMagnetic Energy

- Electric Field + Magnetic Field ➡ 횡파



Classification: Contents

- **Structural(Anatomical) Imaging**
- **Functional Imaging**
- **Macro *vs* Molecular Imaging**

Classification: Display

- **Planar Imaging**
  - Simple projection or shadow image(chest X-ray)
- **Tomographic Imaging**
  - Complicated computer reconstructed image(CT, MRI)
- **2D *vs* 3D Imaging**
- **Stationary *vs* Motion Imaging**

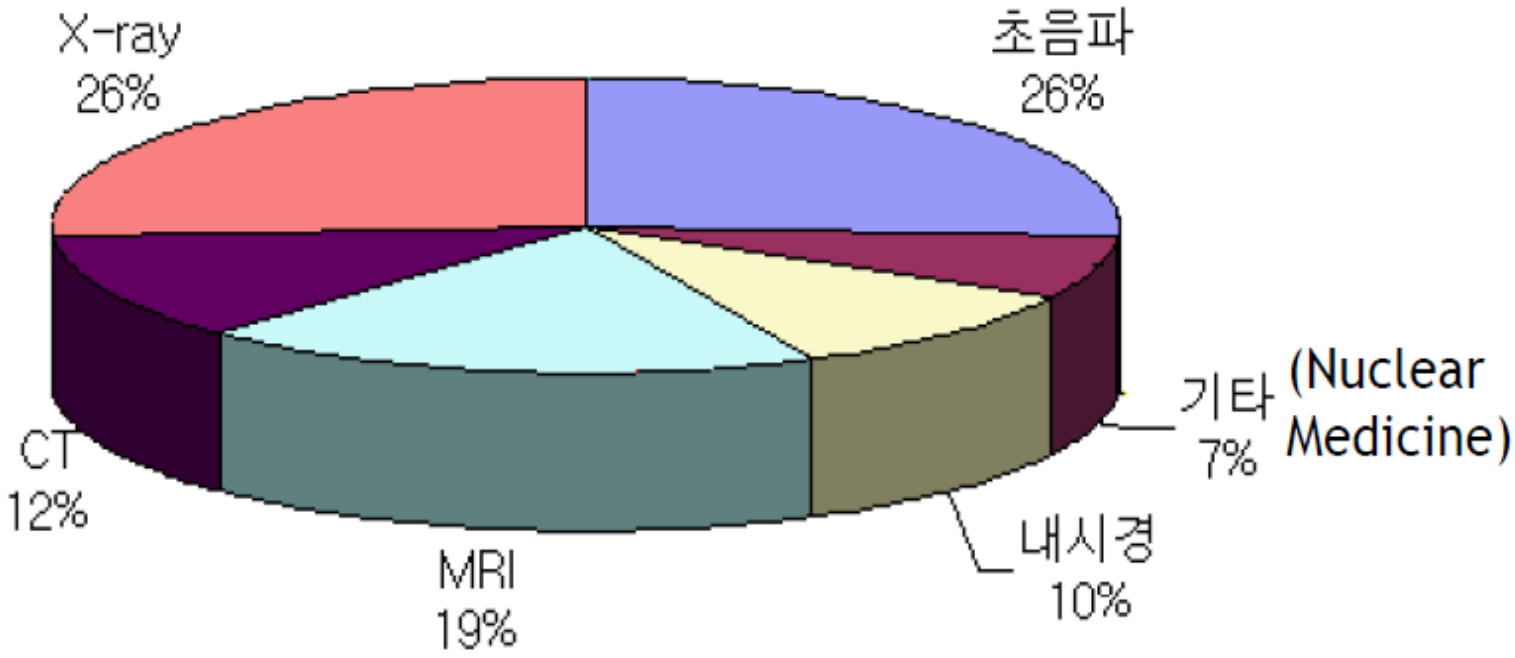
Classification: Technology

- **Hardware : Imaging Modality**
  - **Physics in Imaging Formulation**
  - **Instrumentation**
- **Software : Post-processing**
  - **Restoration**
  - **Enhancement**
  - **Reconstruction**
  - **Classification**
  - **Mathematics & Programming**
  - **PACS(Picture Achival & Communication Systems)**

Classification: Trends

Classical Imaging	Modern Imaging
Special case of modern imaging	Generalization of classical imaging
Direct, intuitive	Indirect, counter intuitive
Image forms directly from the interaction process	Image formed by processing, reformulating, reconstructing
Structural Imaging	Functional Imaging

Medical Imaging Market



Radiography

X-ray: 방사선

- **X**선 : **1895**년 **Wilhelm Roentgen**이 처음 발견하여 뢴트겐선이라고도 함
- 전자가 가속되어 물질에 충돌할 때 파장이 짧은 전자기파**(0.01nm~10nm)**가 발생
- 보통 **x-**선관이라고 하는 일종의 진공방전관을 사용해서 고전압 하에서 가속한 전자를 타깃**(target)**이라는 금속판에 충돌시 켜 발생시킴
- 뢴트겐이 진공방전 연구 중 우연히 발견한 것으로, 그 성질이 물질에 대하여 이상한 투과력을 가지고, 전기장이나 자기장을 주어도 진로를 굽히지 않으며, 거울이나 렌즈에서도 쉽게 반사나 굴절을 일으키지 않는 등 그 정체를 알 수 없다하여 **x-**선이라고 함

X-ray: 방사선

- 방사선이란 에너지를 갖고 있는 일종의 보이지 않는 광선
- 일상생활에서 흔히 경험하는 **1)** 전자렌지의 극초단파 **2)** 라디오와 **TV**의 전파 **3)** 레이더 **4)** 병원에서 진료에 이용되는 **X-RAY** 등 모두가 방사선의 일종
- 방사선의 종류는 크게 알파선, 베타선, 감마선이 있다
- 방사선은 종류에 따라 물질을 투과하는 투과력이 각각 다름
- 방사선은 자연 방사선과 인공 방사선으로 나눌 수 있는데 자연방사선은 땅속의 광물질로부터, 우주로부터, 또 전자기기로부터, 음식물로부터, 우리의 몸 속으로부터 심지어 담배에서도 발생
- 방사선이 가지는 성질이나 인체에 미치는 영향 등 모든 특성은 자연방사선과 인공방사선이 똑같다

X-ray: 방사선

- 방사선이 인체에 미치는 영향을 말할 때 우리는 특별히 밀리렘 **(mrem)**이라는 단위를 사용
- 요즘에는 시버트**(sievert)**라는 새로운 단위를 사용**,** 시버트는 방사선의 형태와는 관계없이 어떠한 방사선이든지 그 방사선으로 인한 일정한 생물학적 효과만을 나타내는 단위
- 적은 양의 방사선량을 나타낼 때는 **1**시버트**(Sv)**의 **1**천분의 **1**인 **1**밀리시버트**(mSv)**를 사용
- **1**밀리시버트는 **100**밀리렘과 같고**,** 병원에서 가슴에 **X-**선을 **1**회 촬영할 때에 약 **0.3mSv**의 방사선을 받는다
- 사람이 **70**만 밀리렘의 방사선을 한꺼번에 전신에 받을 것 같으면 여러 증세를 보이다가 수일 내 에 사망하게 됨

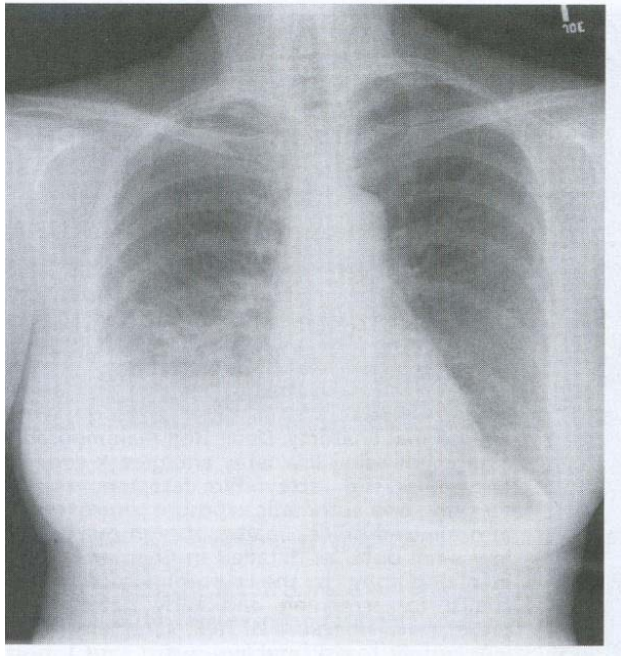
X-ray: 방사선

- **10**만 밀리렘의 방사선을 한꺼번에 전신에 받는다면 구토와 설사 증세 등은 보이지만 생명에는 즉각적인 영향이 없으나, **1**백명 중 **1**명쯤은 몇 년 후에 암에 걸릴 수도 있음
- **1**만 밀리렘의 방사선을 한꺼번에 전신에 받을 경우에는 생물학적으로 별다른 영향이 나타나지 않음
- **500**밀리렘은 보통 사람이 이 정도는 받아도 영향이 없다고 정한 한계선량
- **240**밀리렘은 우리가 일상생활을 하면서 연간 받을 수 있는 평균 자연방사선량

X-ray

Radiography Definition

- **Transmission Imaging**
  - Source→Body →Detector
- **Projection Imaging**
  - Straight line trajectory
    →single point in image
- **Rapid acquisition, low cost, low risk, high diagnostic value**
  - Broken bones, lung cancer, CV disorders



X-ray Discovery

- Report of his discovery of short-wave radiations

- 1st Medical Imaging Technology
- Most widely using MI modality
- By Wilhelm Roentgen:
  - In 1895, Nov. 8
  - 1st X-ray image
  - Most properties of X-ray
  - Roentgenography

Hand of Mrs. Roentgen

The Nobel Prize in **Physics** 1901

Images by Roentgen

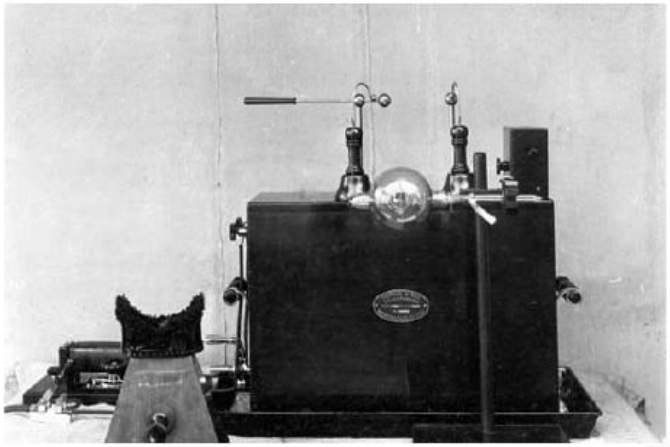
- 22nd Dec 1895
- Wife of Roentgen
- "I have seen my death"

- 23rd Jan 1896
- Hand of Albert von Kölliker
  - Swiss anatomist & physiologist

- These days

X-ray Machine by Edison

X-ray machine in 1896

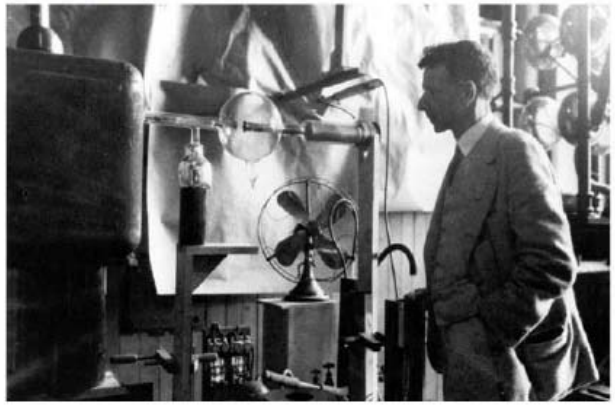


General Electric is formed (1892)

GE Monogram (1900)

GE from Edison General Electric Company

X-ray tube in 1913



CT in 1976

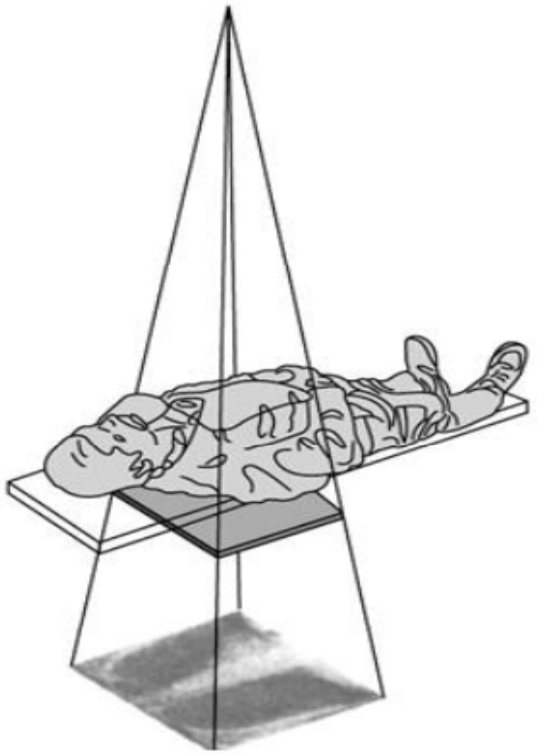
Common Imaging Modalities

- Projection radiography (X-ray)
- Computed Tomography (CT scan or CAT Scan)
- Nuclear Medicine (SPECT, PET)
- Ultrasound imaging
- MRI

Projection vs. Tomography

- **Projection**

A single image is created for a 3D body, which is a "shadow" of the body in a particular direction (integration through the body)

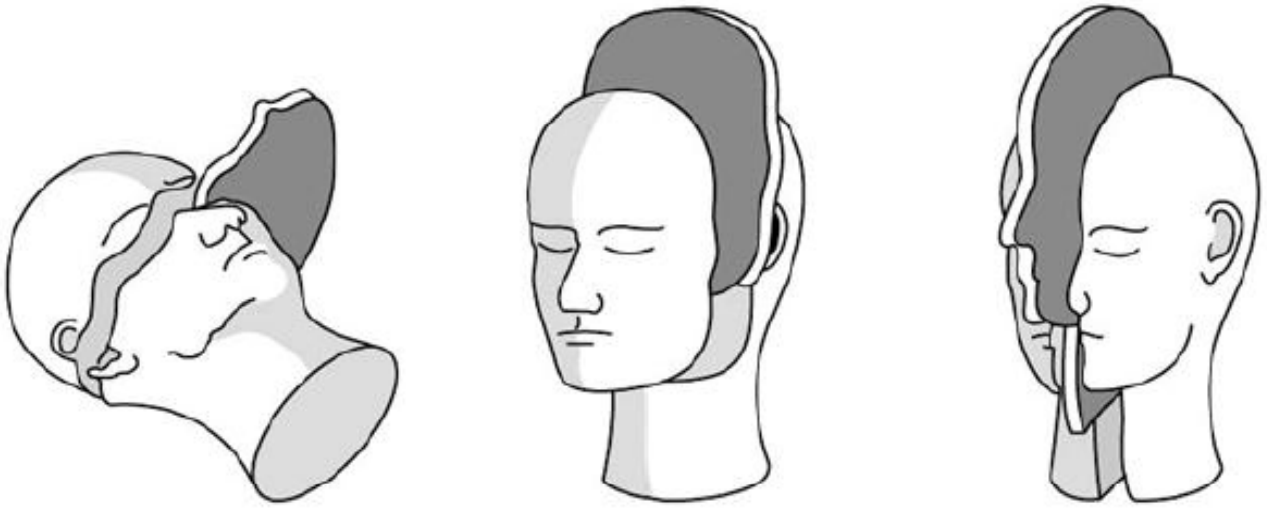


Projection vs. Tomography

- **Tomography**

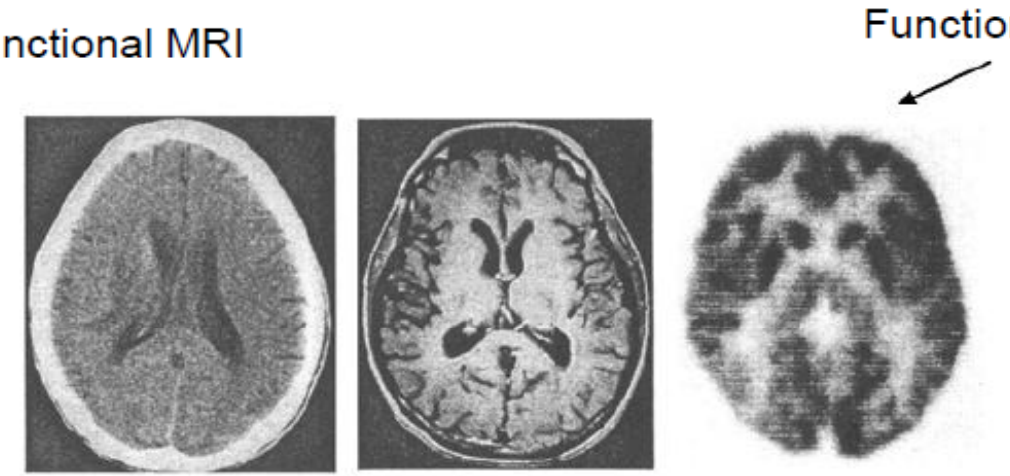
A series of images are generated, one from each slice of a 3D object in a particular direction (axial, coronal, sagital)

To form image of each slice, projections along different directions are first obtained, images are then reconstructed from projections (back-projection, Radon transform)



Anatomical vs. Functional Imaging

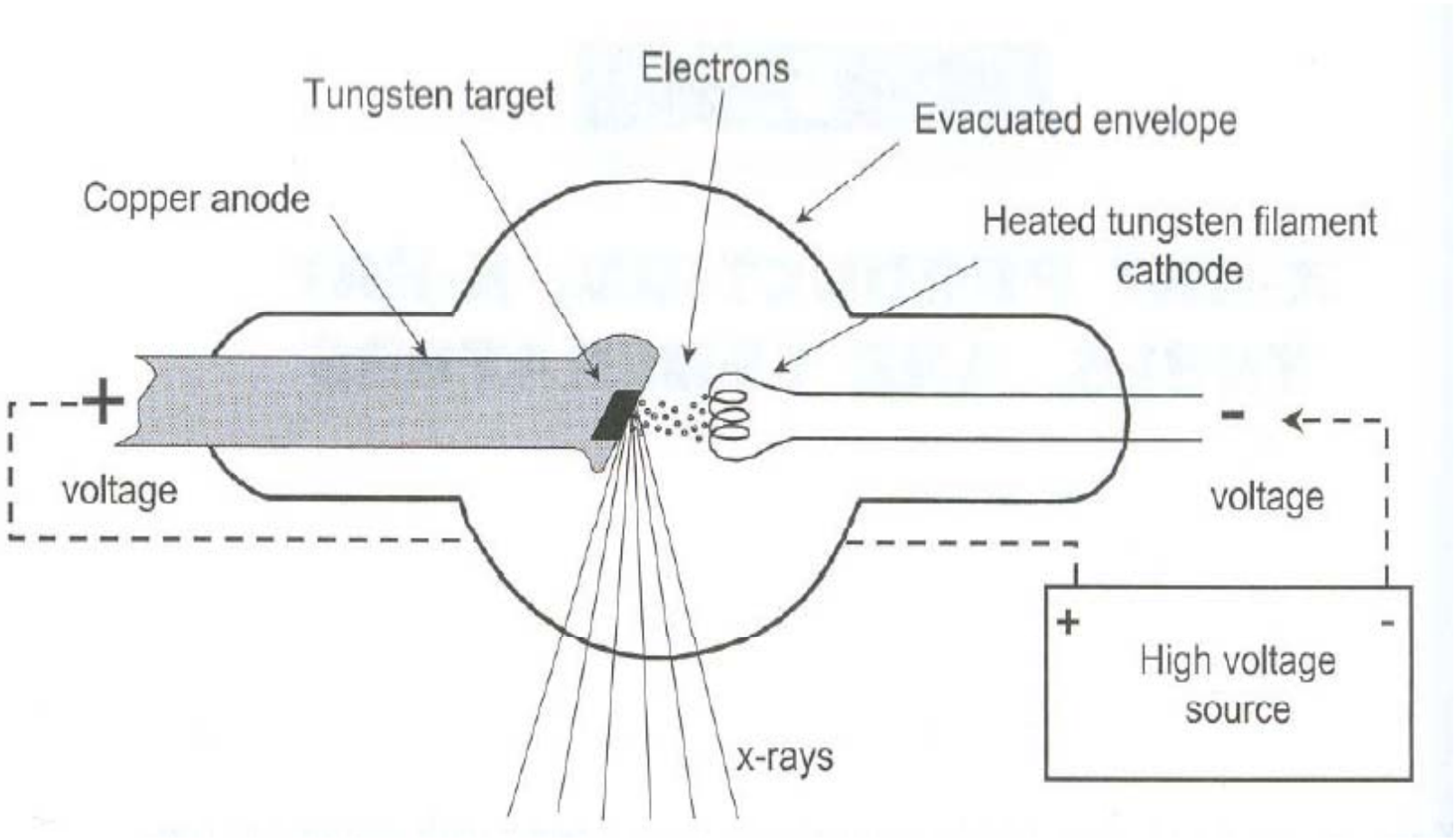
- Some modalities are very good at depicting anatomical (bone) structure
  - X-ray, X-ray CT
  - MRI
- Some modalities do not depict anatomical structures well, but reflect the functional status (blood flow, oxygenation, etc.)
  - Ultrasound
  - PET, functional MRI



Distribution of X-ray

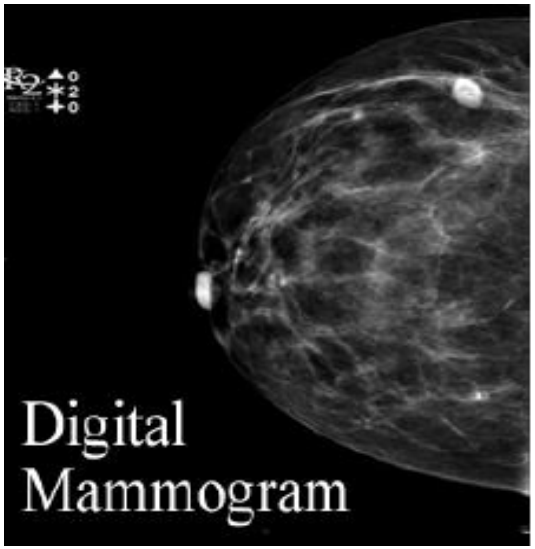
- **Input: Short duration of X-ray**
  - Uniform distribution from X-ray tube
- **Modified by body tissues**
  - X-ray attenuation: **Information**
  - While transmitting body tissue
  - By Absorption, scattering
- **Detection**
  - Photographic film: Screen-film Radiography
  - Electronic detector

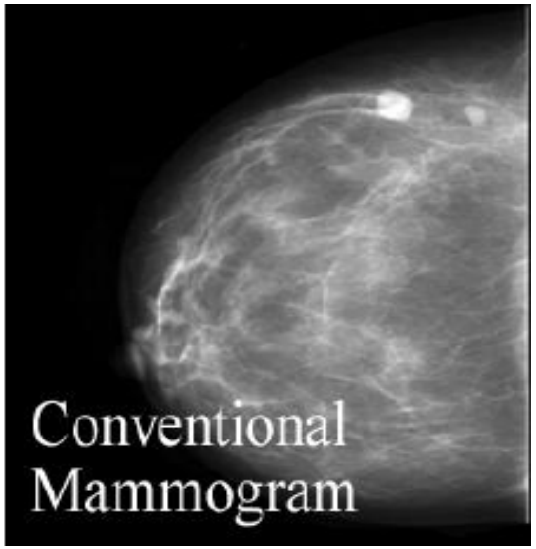
X-ray Generation



Mammography

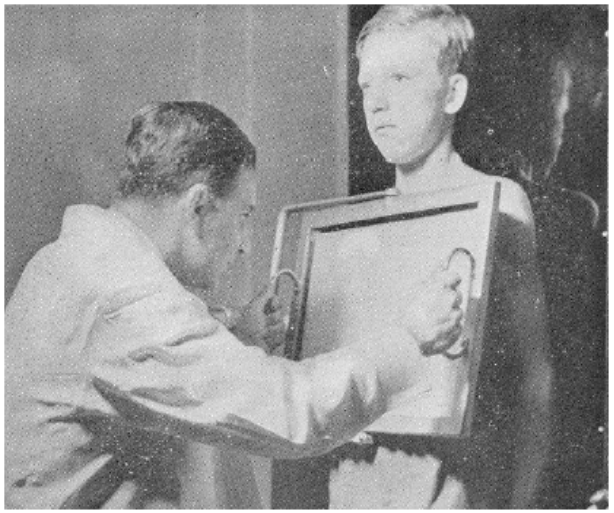
- **Radiography of Breast**
  - **Screen asymptomatic women for breast cancer**
    - ✓ **Masses and calcification**
- **Transmission & Projection Imaging Mode**
- **High sensitivity, low cost, excellent benefit to the risk**





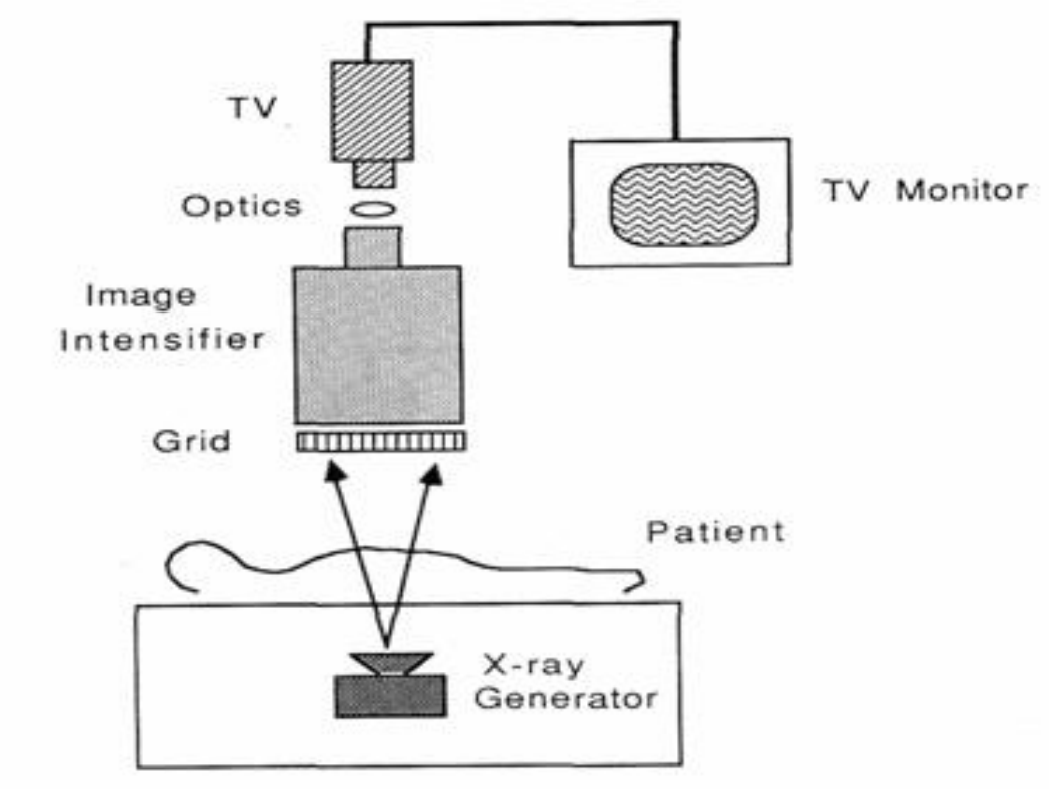
Fluoroscopy

- **Continuous acquisition of X-ray image**
  - **Real-time X-ray movie**
  - **Scotopic vision**
  - **Real-time feedback:**
    - ✓ **Positioning catheter**
  - **Anatomical motion:**
    - ✓ **Heart, esophagus**
  - **Lower Radiation dose**



- **Transmission & Projection Imaging Mode**

Fluoroscopy



Angiography

- **Fluoroscopic system for vessels**
  - **Diagnosis of vascular disease**
  - **Assisting interventional procedure**
    - ✓ **Stent placement, balloon angioplasty, thrombosis**
- **Digital subtraction angiography[DSA]**

Questions ?