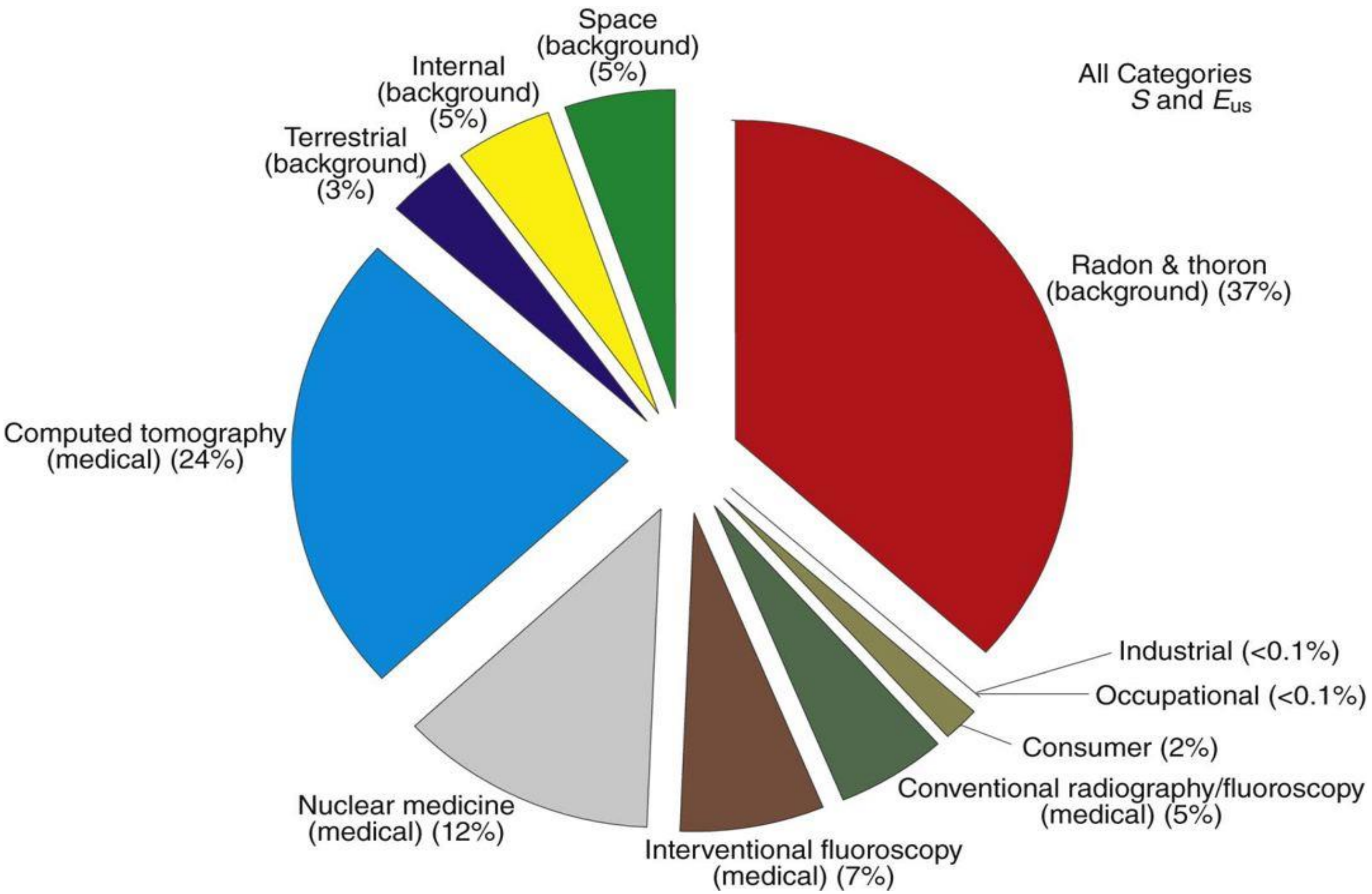
Characteristics of X-Radiation - 2

Sources of Radiation

Natural

Artificial (Man Made)

Diagram Of Radiation Dose From Natural And Man Made Sources (2006)
Average Annual Individual Effective Dose From All Sources Is 6.3 mSv



Natural Radiation

- Has always been a part of the human environment
- Results in an estimated average annual dose of 3.0 mSv (Radon being the biggest contribution)
- The ionizing radiation from environmental sources is called **natural background radiation**
- 3 Components:
- **Terrestrial** - from radioactive materials in the earth's crust
- **Cosmic** - from sun (solar) and beyond solar system (galactic)
- **Internal** - radiative atoms (radionuclides) that make up some of the body tissue

Man Made (Artificial) Radiation

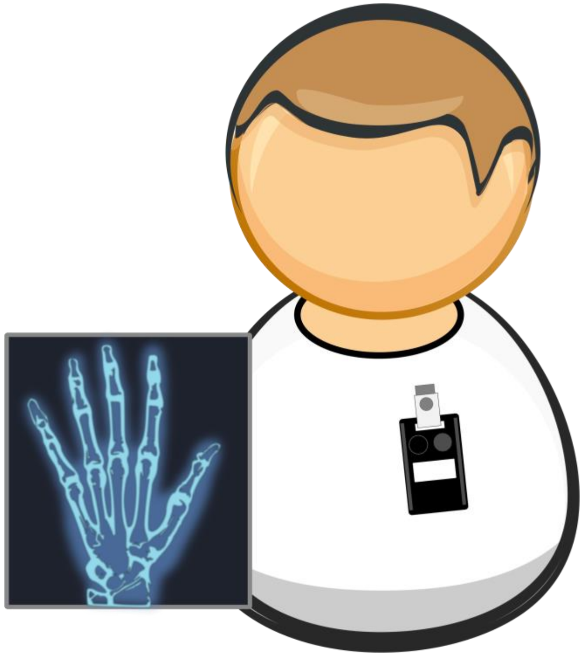
- Radiation created by humans
- Contributes about 3.3 mSv to average annual radiation exposure of US population
- *Include the following:*
  - Consumer products containing radioactive material
  - Air travel
  - Nuclear fuel for generation of power
  - Atmospheric fallout from nuclear weapons testing
  - Nuclear power plant accidents
  - Nuclear power plant accidents as a consequence of natural disasters
  - Medical radiation

This Guy Started the Medical

- Discovered in 1895
- Ability of X-Ray to cause injury soon became apparent.

Wilhelm Rontgen

Medical Radiation



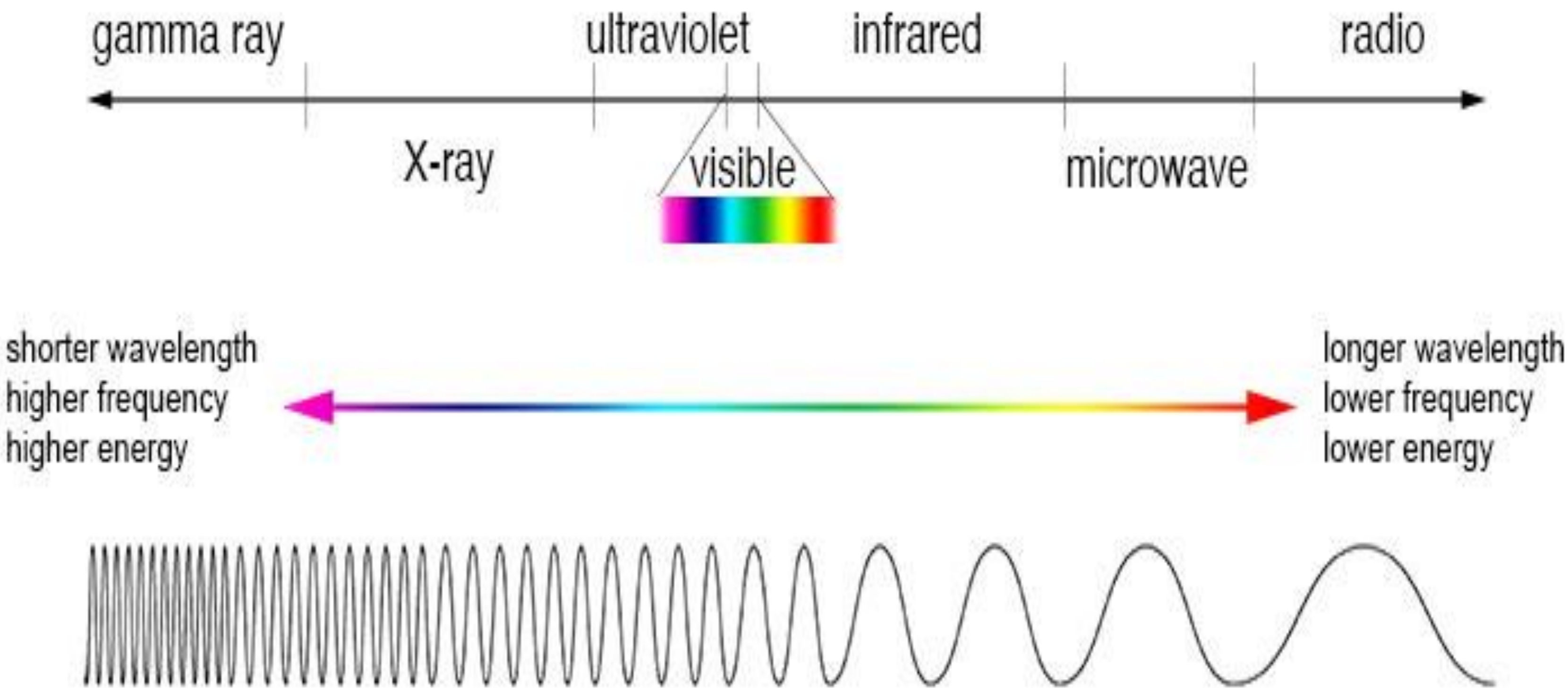
- Man made

- NCRP report No. 93 (**1988**), medical radiation estimated to contribute 0.54 mSv

- NCRP report No. 160 (**2009**) reflects that medical radiation accounted for approximately 3.2 mSv (increase by a factor of 5)

- Largely due to increase of radiation procedures (especially CT)

Electromagnetic Spectrum



Non-Ionizing Radiation

- The following are termed nonionizing radiation:
  - Low-energy ultraviolet radiation
  - Visible light
  - Infrared rays
  - Microwaves
  - Radiowaves

- They are nonionizing because they do not have sufficient kinetic energy to eject electrons from the atom

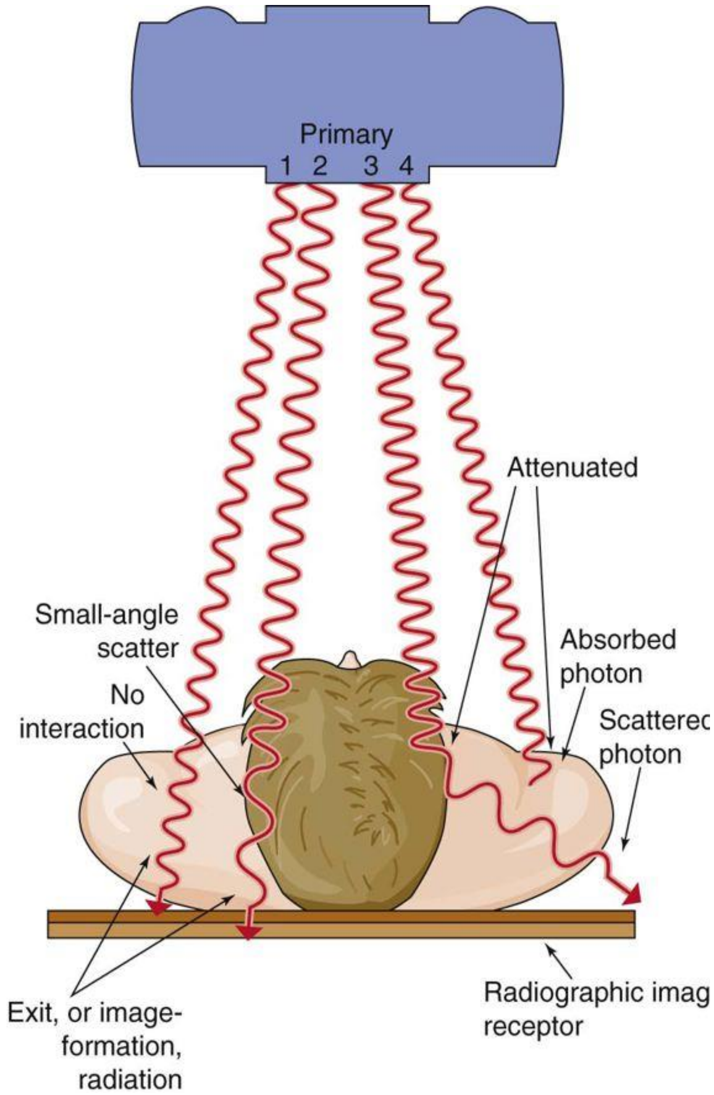
Ionizing Radiation

- This type of radiation produces positively and negatively charged particles.
- This production may cause injury in normal biologic tissue.
- Since we know the potential injury ionizing radiation may cause, we as CT technologists employ effective methods to limit or eliminate those risks.
- These radiations include:
  - X-rays (CT)
  - Gamma Rays (Nuclear medicine and Radiation Therapy)
  - High-energy ultraviolet radiation (above 10 eV)

Attenuation

- When an x-ray beam passes through a patient, it goes through a process called *attenuation*
  - *Attenuation is the reduction in the number of primary photons in the x-ray beam that reach the predefined destination through absorption and scatter.*

- Some of the x-ray photons pass through the patient to the image receptor without interacting – this is called *direct transmission*

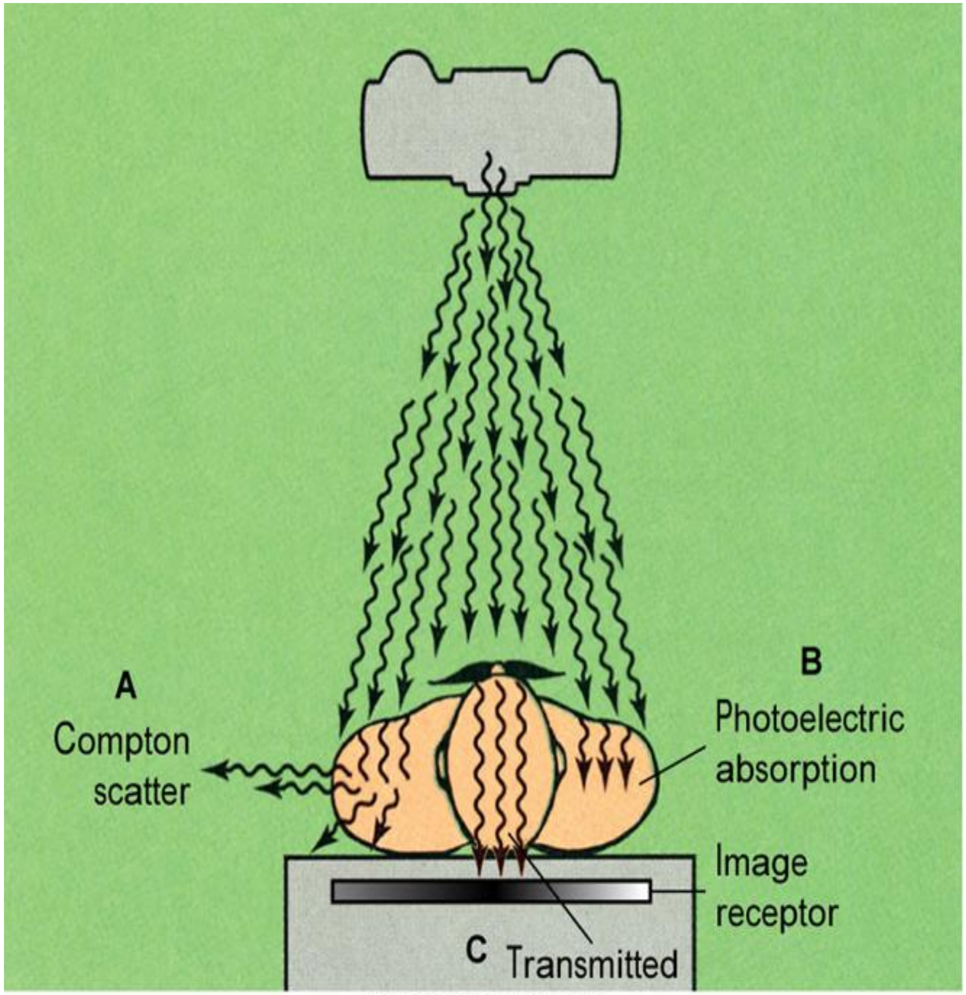


ADVANCED HEALTH EDUCATION CENTER®
EDUCATION ▲ STAFFING ▲ CONSULTING

Differential Absorption

- Differential absorption occurs because of Compton scattering, photoelectric effect and the x-rays that are transmitted through the patient.

- The x-ray image is the produced from the difference of these interactions



The 5 types of Radiation Interactions with Matter

1. Coherent Scattering
2. **Photoelectric Absorption**
3. **Compton Scattering**
4. Pair Production
5. Photodisintegration

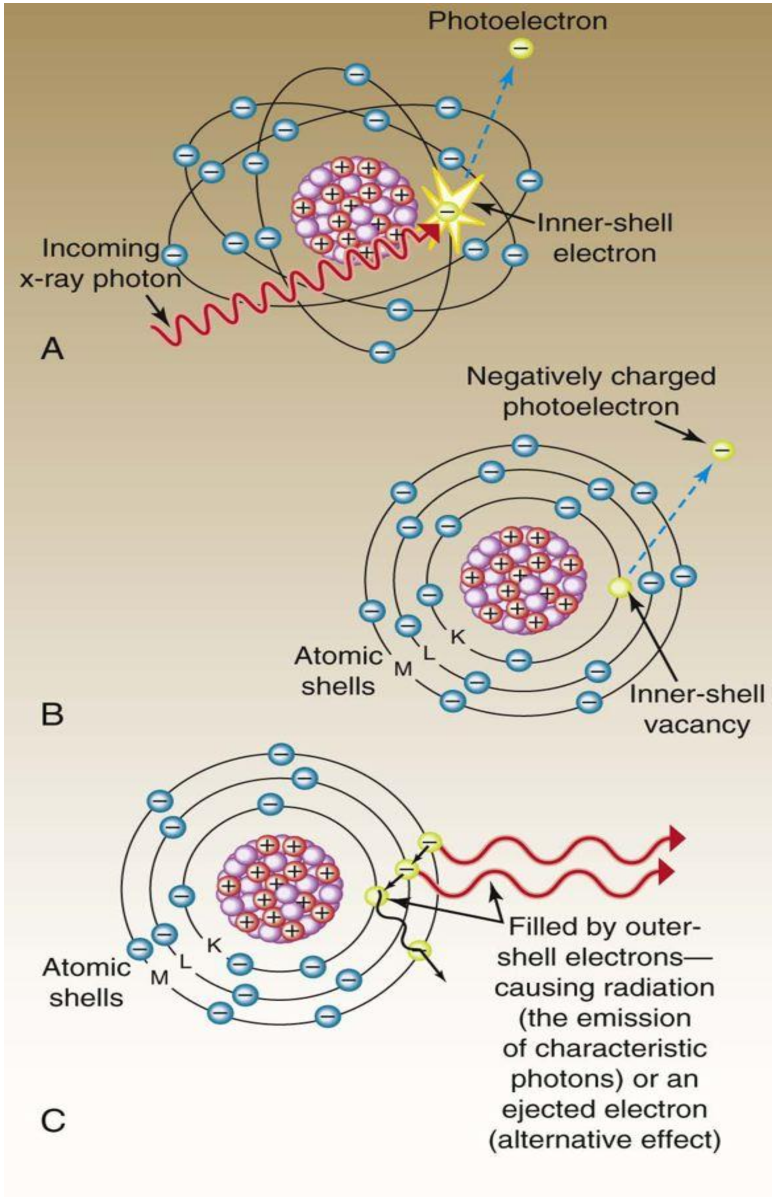
Important in Radiography

Photoelectric Absorption

- Interaction between x-ray photon and inner-shell electron
- The x-ray photon surrenders all energy to the inner shell electron
- The electron is then ejected from its inner shell creating a vacancy
- The ejected orbital electron is called a *photoelectron*

Photoelectric absorption (Cont'd)

- The photoelectron is usually absorbed in the human body – thus increasing patient dose and contributes to biologic damage of tissue
- The vacancy in the inner shell will cause a cascade effect
- With each outer shell electron dropping into an inner shell, a releases of energy is caused
- Release energy is in the form of a characteristic photon or characteristic x-ray



PhotoElectric Absorption (Cont'd.)

- The probability for PE interactions depends on the energy of the incident x-ray and the atomic number of the atoms in the tissue.

- PE interactions contribute to patient dose and are more likely to occur when:
  - The relatively low kVp is used
  - The atomic number of the absorber is high
  - Mass and body part thickness increases

- As Absorption increase so does the potential for biological damage

Compton Scattering

- Also called:
  - Incoherent Scattering
  - Inelastic Scattering
  - Modified Scattering

- Responsible for most scattered radiation produced during procedures

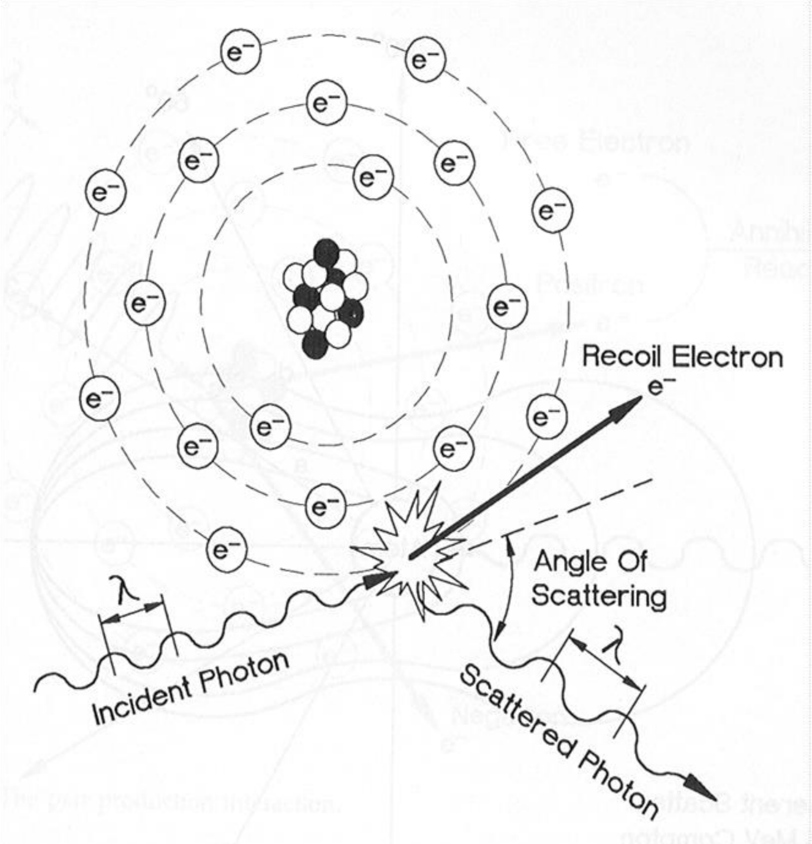


Figure 11–4. The Compton scatter interaction.

Compton Scattering (Continued)

- Interaction occurs when an incoming x-ray photon interacts with a outer shell electron
- In this interaction the x-ray photon surrenders some energy to dislodge the electron from the outer shell
- The x-ray photon loses energy and changes direction (called a *compton scattered photon*)

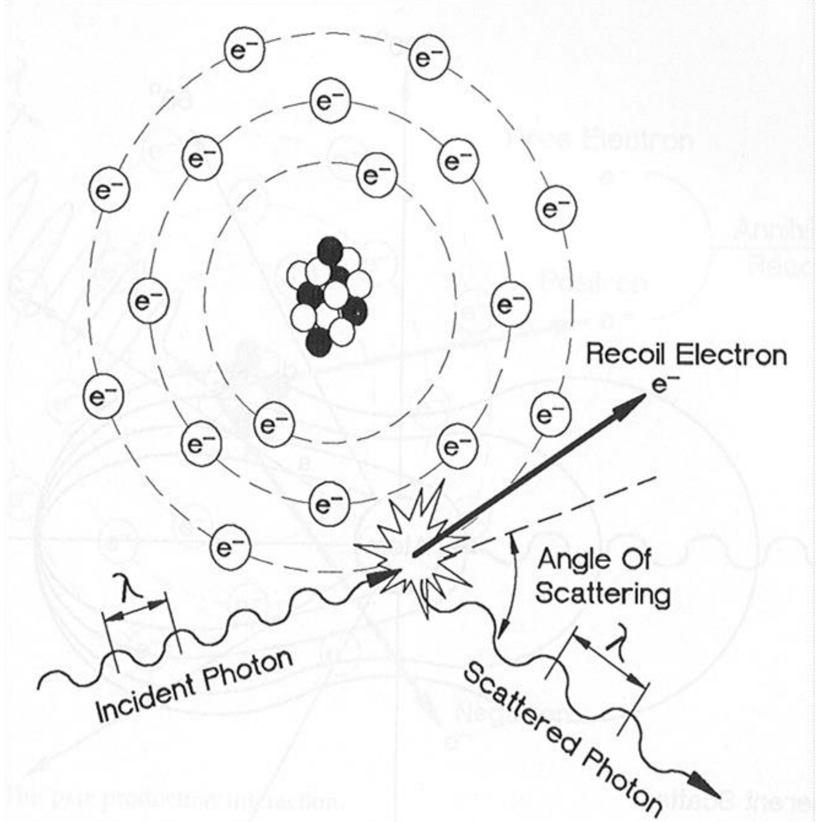
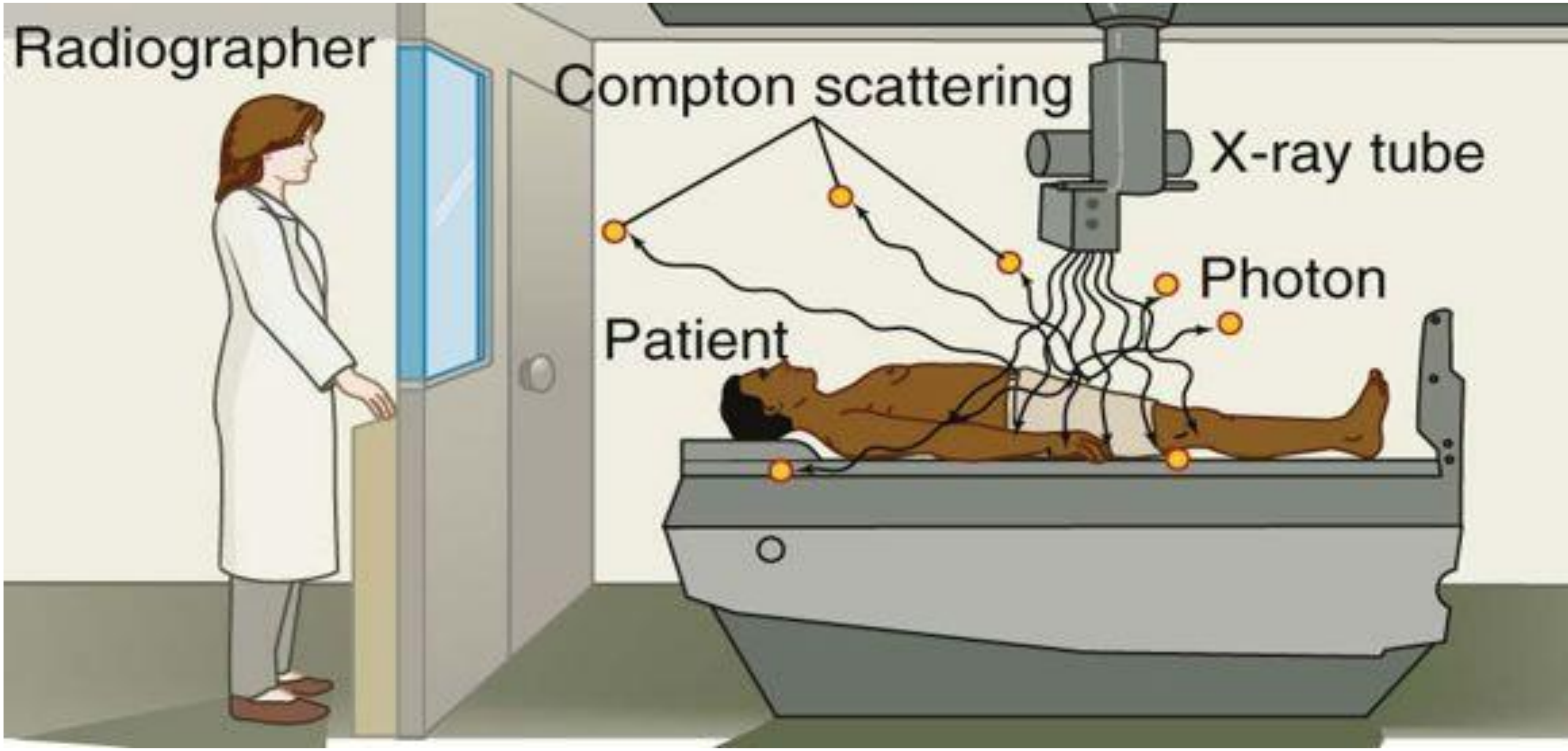


Figure 11–4. The Compton scatter interaction.

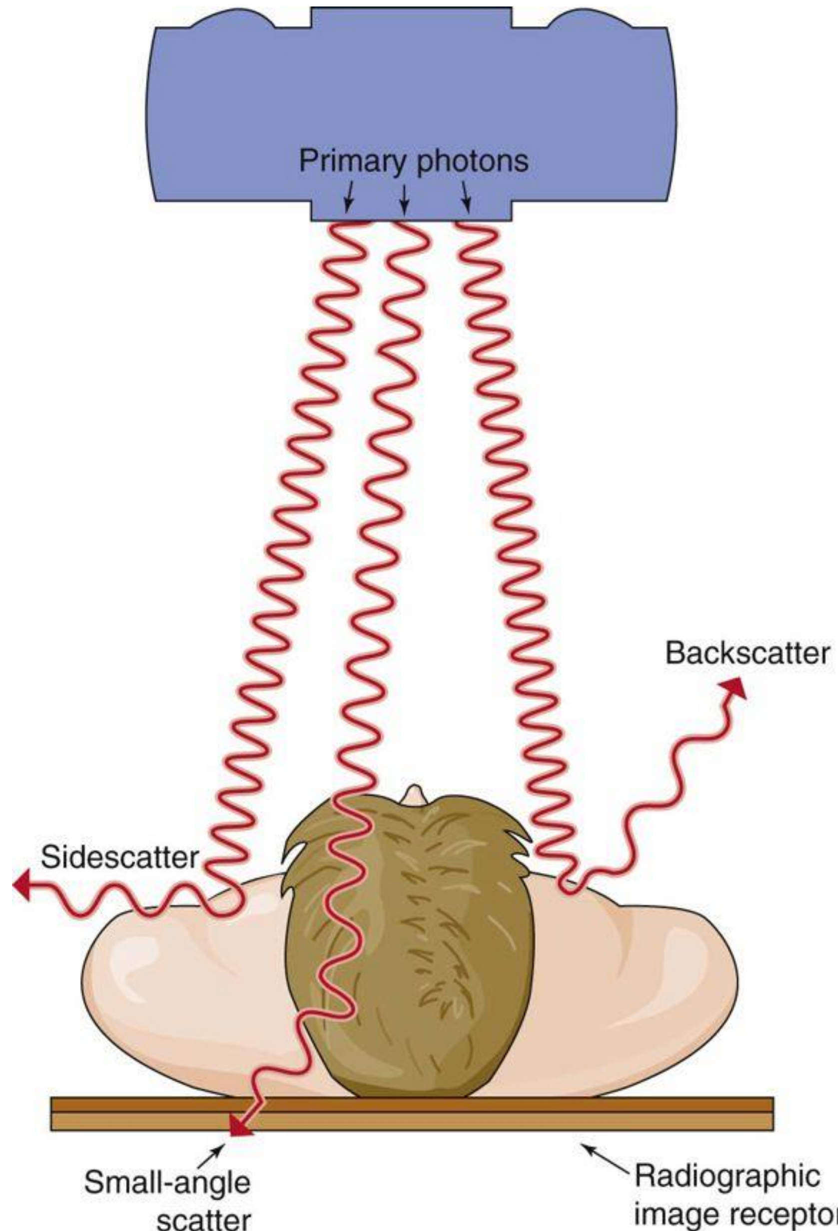
Compton Scattering (Cont'd)



What does this image tell you about compton scattering?

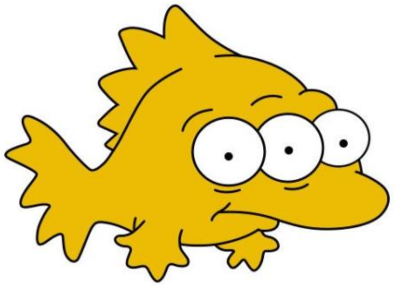
Compton Scattering (Cont'd.)

- Compton scatter photons contribute to radiographic fog and degrades image quality
- When utilized in fluoroscopy – the Compton scatter photons may expose personnel who are in the room
- Increase x-ray energy (kVp) to reduce Compton scatter



Biologic Damage Potential

- Biological damage can stem from ionization radiation
- Cellular damage occurring at the atomic level can result in molecular change (Ex. Mutations, Cataracts, Leukemia, Etc.)

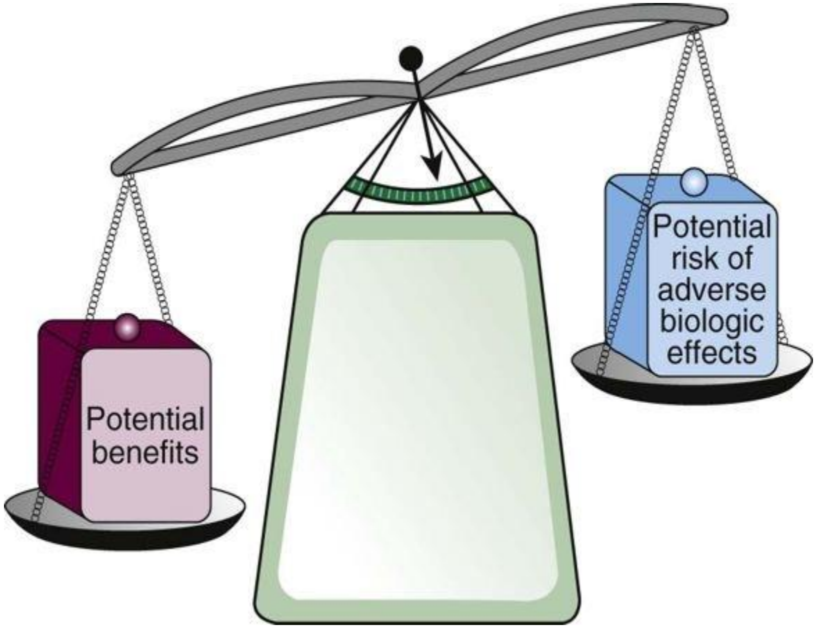


Benefit Vs Risk

In radiography - risk is the possibly of inducing radiogenic cancer or genetic defect after irradiation.

Medical imaging equipment and radiation safety standards have improved greatly - reduced risk from imaging procedures for both patients and radiographers

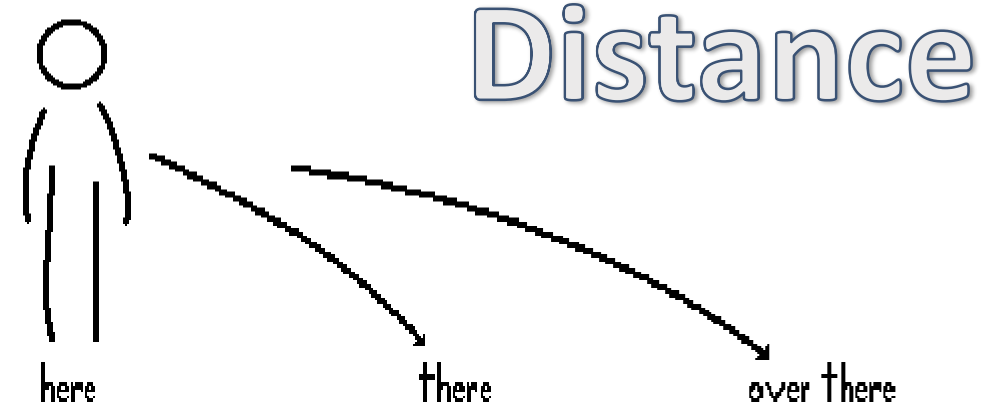
Patients who understand the **benefit** of imaging (through proper education/information) before the exam are more like to overcome the 'radiation fear'



Cardinal Rules of Radiation Protection?

Time

Distance



Shielding

Time, Distance, and Shielding

For Patient Exposure:

- Reduce amount of x-ray "On" time
- Use as much distance as possible
- Always shield patients when possible

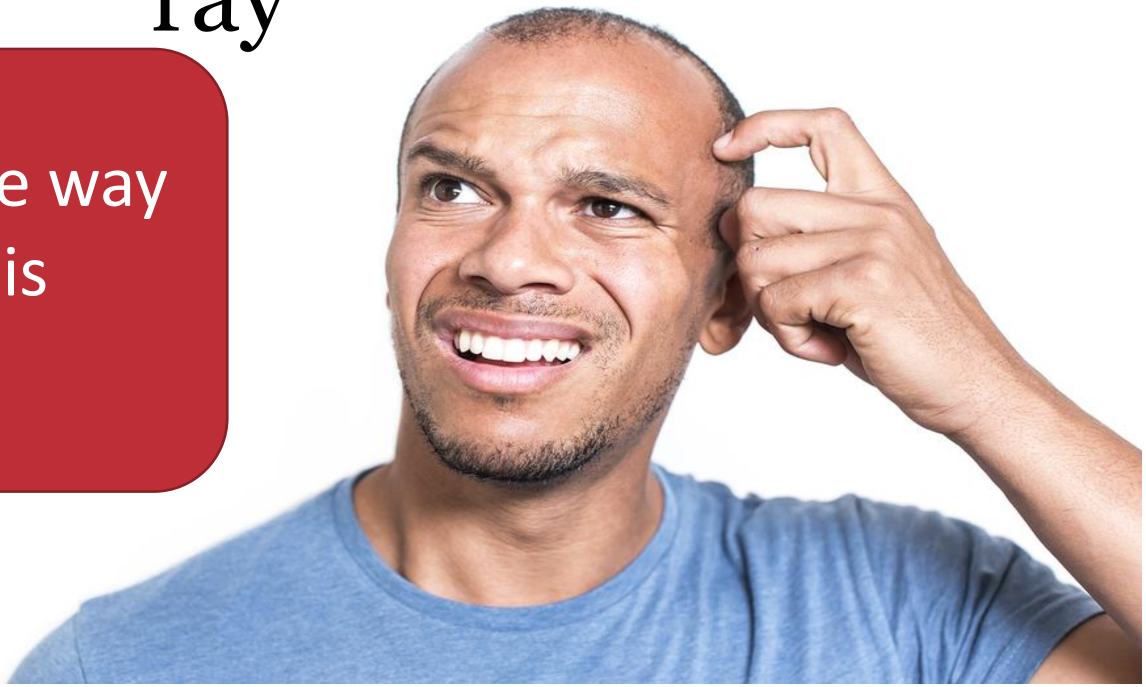
For Occupational Exposure:

- Shortening length of time spent in room
- Standing as far away from x-ray beam as possible
- Wearing shielding

“Are X-rays Safe?”

“Yes, Sir - you only get .06 mSV (millisieverts) of radiation for a chest x-ray”

Is this an effective way to address this question?



Is this an effective way to address this question?

- Probably not -
  - Any explanation where we give actual values to patients may be difficult for them to understand because:
    - 1) the received dose of radiation can be measured in several different units
    - 2) scientific units for radiation is not comprehensible by most patients

We are NOT trying to provide high scientific accuracy - but we are trying to calm anxiety about radiation with a understandable and correct answer.

Background Equivalent Radiation Time (BERT)

- Background Equivalent Radiation Time (BERT) is a way radiographers can reduce anxiety and fear through a method that provides a little more clarity and understanding.

- This method does this by:
  - Comparing the amount of radiation received during a medical procedure to that amount of natural background radiation they may receive over a period of time.

- This method is actually recommended by the US National Council of Radiation Protection and Measurements (NCRP)

Correct conversations utilizing BERT

How much radiation will I receive from this chest x-ray?

"The radiation you will receive is equal to what would be received while spending 10 days in your natural environment"

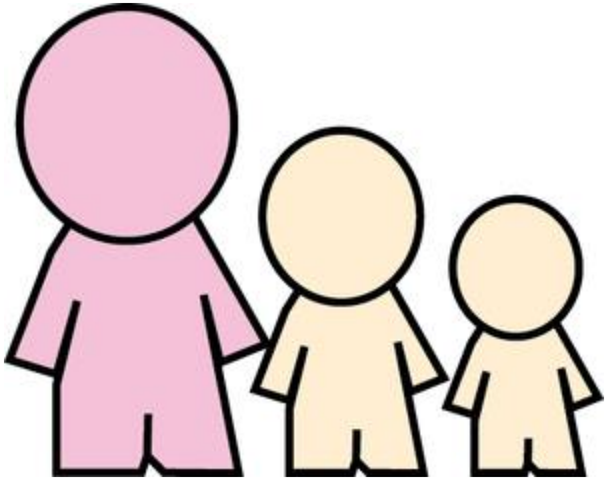
BERT

- BERT is based on the annual US population exposure of approximately 3 millisieverts per year.
- BERT does not imply radiation risk; it is used for comparison
- BERT emphasized that radiation is an innate part of our environment
- BERT is easy for patients to comprehend
- Should not actually use the term BERT in the explanation

Radiation Sensitivity of Children

- Children are more sensitive to radiation than are adults
  - Studies of children irradiated at a young age shows an increase in cancer incidences in later stages of life

But what are we doing to protect children from radiation?



Alliance for Radiation Safety in Pediatric Imaging

- Founded in 2007 – purpose to reduce the radiation dose for pediatric patients and raise awareness of detrimental exposure of children to radiation
- Studies showed in 2007, many physicians unaware of the risk posed by CT to children
- The Alliance put forth the need for dose reduction protocols when scanning pediatrics and decrease use of high radiation exposure (such as CT) in pediatrics
- Studies found from 2003-2010, there were decreased trends in CT use in favor of alternative modalities in pediatrics.

Image Gently Campaign

- January 2008 – the alliance launches the *Image Gently Campaign*
  - Mainly involved in CT

- This campaign: Aimed to spread information on pediatric dose reduction

- Radiology departments or individual radiologic technologists can "pledge" to image gently. The pledge includes the following:

  - Make the image gently message a priority in staff communications each year.

  - Review the protocol recommendations, and, where necessary, implement adjustments to practice processes.

  - Communicate openly with parents.

2018 IMAGE WISELY®

Radiation Safety in Adult Medical Imaging

- Image Wisely Campaign formed by the American College of Radiology (ACR) and the Radiological Society of North America (RSNA)
  - To address concerns about the increase of public exposure to ionizing radiation from medical imaging
  - To address the need of lowering the amount of radiation used in imaging studies and eliminating unnecessary procedures

Monitoring and Reporting Dose

- More demanding reporting of patient dose is being seen
  - In CT and IR patient dose recording is becoming the norm
    - Some states even require a log of skin dose for each patient be kept as part of the patient's record
- Indications of dose reporting being a requirement for all modalities in radiology is being seen
- Facilities often have alert levels

- When patient dose has exceeded a certain dose level – radiologist is notified (some times even the medical physicists may be called)

NCRP REPORT NO. 184

- Report published (2019) that showcases a reduction of medical radiation exposure by 15 – 20% from 2006 to 2016.

"Changes in technology as well as campaigns to increase dose awareness and reduce dose among the medical community and the public seem to be having the desired effect."

- Dr. Mahadevappa Mahesh, co-chair of the NCRP Report and Professor of Radiology and Radiological Science at the Johns Hopkins University School of Medicine.