PHYSICS OF DIAGNOSTIC RADIOLOGY LABORATORY

FOR 3RD YEAR MEDICAL PHYSICS STUDENTS

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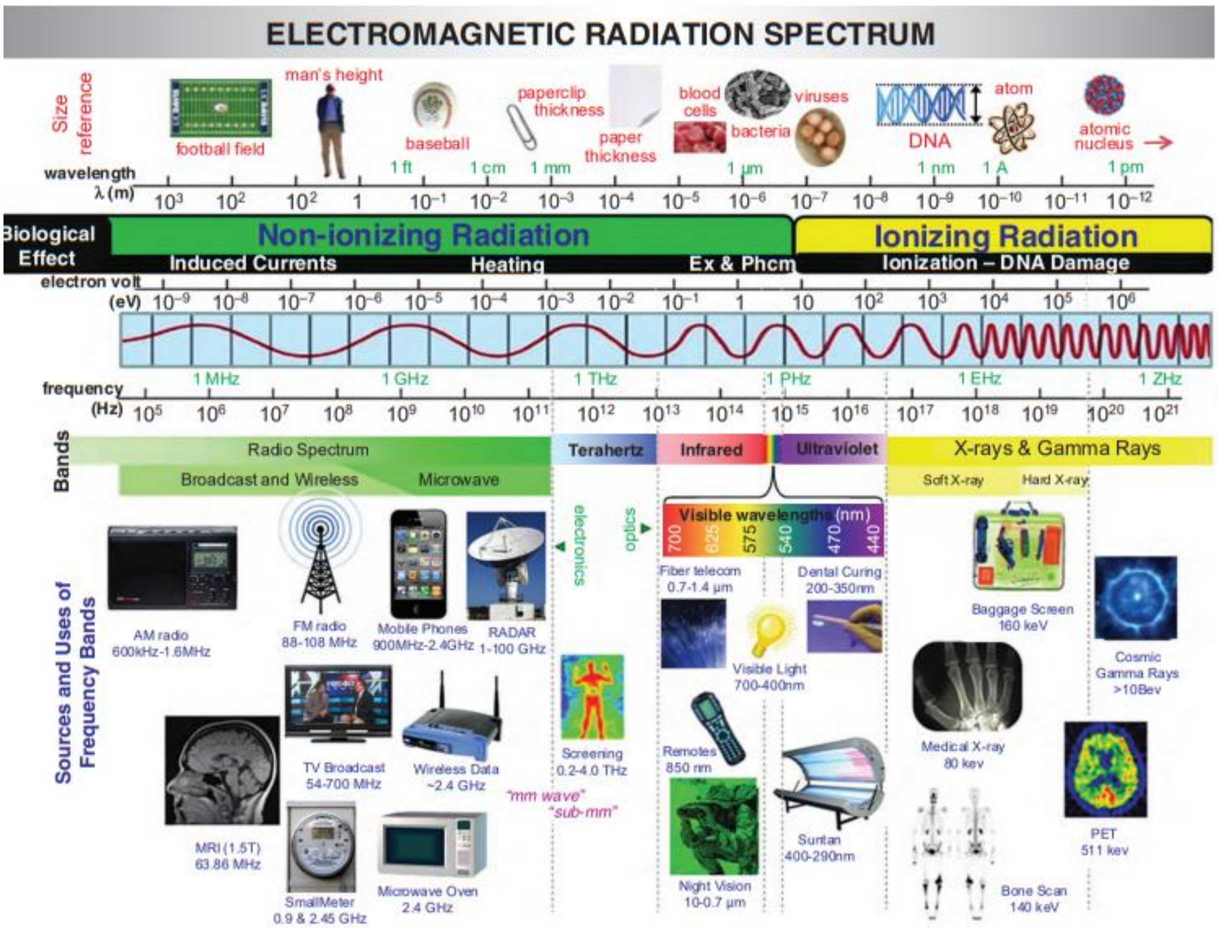
Classification of Radiation

Radiation may be classified as electromagnetic or particulate, with electromagnetic radiation including visible light, infrared and ultraviolet, X rays and gamma rays (Fig. 1), and particulate radiation including electrons, positrons, protons and neutrons.



■ FIGURE 2-1 The EM spectrum.

Electromagnetic radiation

Electromagnetic waves can, like all waves, be characterized by their amplitude, wavelength (λ), frequency (ν) and speed. The amplitude is the intensity of the wave. The wavelength is the distance between identical points on adjacent cycles. The frequency is the number of complete wave oscillations per unit time. The speed of the wave is equal to the product of the frequency and the wavelength, and its magnitude depends upon the nature of the material through which the wave travels and the frequency of the radiation. In a vacuum, however, the speed for all electromagnetic waves is a constant, usually denoted by c, and in which case:

$c = \lambda\nu$

For X rays, wavelength is usually expressed in nanometres (nm) (1 nm = 10^{-9} m) and frequency is expressed in Hertz (Hz) (1 Hz = 1 cycle/s = 1 s^{-1}

When interactions with matter are considered, electromagnetic radiation is generally treated as series of individual particles, known as photons. The energy of each photon is given by: $E = h\nu$

where the constant h is known as Planck’s constant. In diagnostic radiology, the photon energy is usually expressed in units of keV, where 1 electronvolt (eV) is the energy received by an electron when it is accelerated across of a potential difference of 1 V.

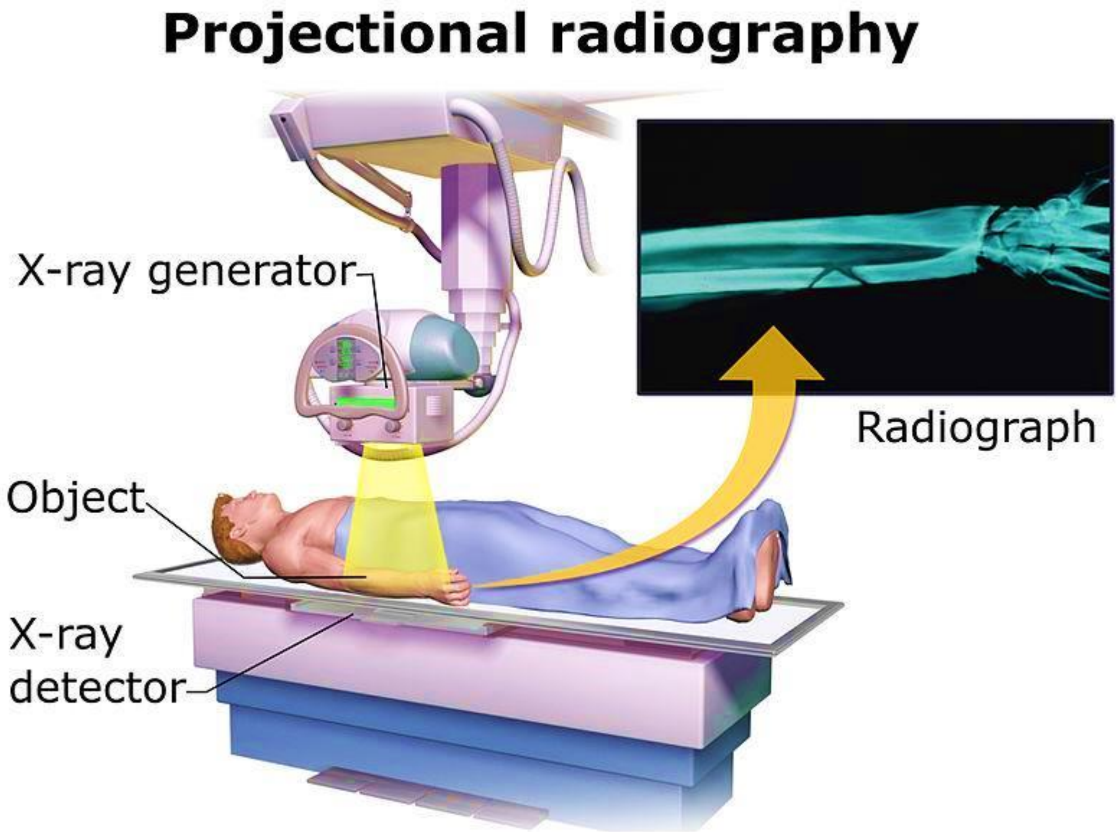
Particulate radiation

In diagnostic radiology, the only particulate radiation that needs to be considered is the electron. This has a rest mass of 9.109×10^{-31} kg and a rest energy of 511 keV

Ionizing and non-ionizing radiations

Radiation is classified as ionizing or non-ionizing, depending on its ability to ionize matter: ● Non-ionizing radiation cannot ionize matter ● Ionizing radiation can ionize matter,

either directly or indirectly — Directly ionizing radiation: Fast charged particles that deposit their energy in matter directly, through many small Coulomb (electrostatic) interactions with orbital electrons along the particle track. — Indirectly ionizing radiation: X or gamma ray photons or neutrons that first transfer their energy to fast charged particles released in one or a few interactions in the matter through which they pass. The resulting fast charged particles then deposit their energy directly in the matter. The minimum energy required to ionize an atom, i.e. to remove an electron, is known as the ionization potential. For elements, its magnitude ranges from a few electronvolts for alkali metals to 24.5 eV for helium. For water, it is 12.6 eV. Electromagnetic radiation of frequency higher than the near-ultraviolet region of the electromagnetic spectrum is ionizing, whereas electromagnetic radiation with energy below the far-ultraviolet region (e.g. visible light, infrared and radiofrequency) is non-ionizing.



Radiation is energy that travels through space or matter. Two categories of radiation of importance in medical imaging are electromagnetic (EM) and particulate.

Electromagnetic Radiation Radio waves, visible light, x-rays, and gamma rays are different types of EM radiation. EM radiation has no mass, is unaffected by either electric or magnetic fields, and has a constant speed in a given medium. Although EM radiation propagates through matter, it does not require matter for its propagation. Its maximal speed (2.998×10^8 m/s) occurs in a vacuum. In matter such as air, water, or glass, its speed is a function of the transport characteristics of the medium. EM radiation travels in straight lines; however, its trajectory can be altered by interaction with matter. The interaction of EM radiation can occur by scattering (change in trajectory), absorption (removal of the radiation), or, at very higher energies, transformation into particulate radiation (energy to mass conversion). EM radiation is commonly characterized by wavelength (l), frequency (n), and energy per photon (E). EM radiation over a wide range of wavelengths, frequencies, and energy per photon comprises the EM spectrum. For convenient reference, the EM spectrum is divided into categories including the radio spectrum (that includes transmissions from familiar technologies such as AM, FM, and TV broadcasting; cellular and cordless telephone systems; as well as other wireless communications technologies); infrared radiation (i.e., radiant heat); visible, ultraviolet (UV); and x-ray and gamma-ray regions (Fig.N). Several forms of EM radiation are used in diagnostic imaging. Gamma rays, emitted by the nuclei of radioactive atoms, are used to image the distributions of radiopharmaceuticals. X-rays, produced outside the nuclei of atoms, are used in radiography, fluoroscopy, and computed tomography. Visible light is produced when x-rays or gamma rays interact with various scintillators in the detectors used in several imaging modalities and is also used to display images. Radiofrequency EM radiation, near the FM frequency region, is used as the excitation and reception signals for magnetic resonance imaging.

Radiography

Radiography was the first medical imaging technology, made possible when the physicist Wilhelm Roentgen discovered x-rays on November 8, 1895. Roentgen also made the first radiographic images of human anatomy. Radiography defined the field of radiology and gave rise to radiologists, physicians who specialize in the interpretation of medical images. Radiography is performed with an x-ray source on one side of the patient and a (typically flat) x-ray detector on the other side. A short-duration (typically less than ½ second) pulse of x-rays is emitted by the x-ray tube, a large fraction of the x-rays interacts in the patient, and some of the x-rays pass through the patient and reach the detector, where a radiographic image is formed. The homogeneous distribution of x-rays that enters the patient is modified by the degree to which the x-rays are removed from the beam (i.e. attenuated) by scattering and absorption within the tissues. The attenuation properties of tissues such as bone, soft tissue, and air inside the patient are very different, the radiographic image is a picture of this x-ray distribution. The detector used in radiography can be photographic film (e.g. screen-film radiography) or an electronic detector system (i.e. digital radiography).

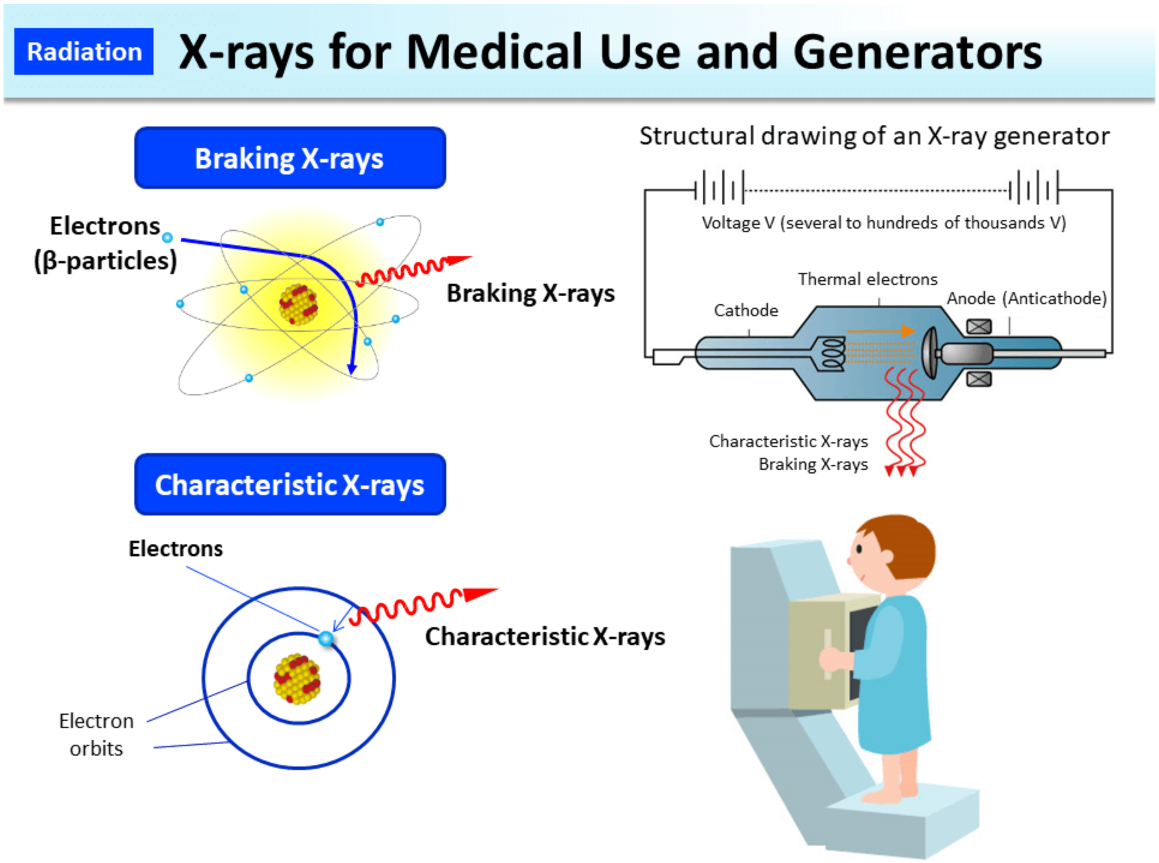
There are many types of medical imaging procedures, each of which uses different technologies and techniques. Computed tomography (CT), fluoroscopy, and radiography ("conventional X-ray" including mammography) all use ionizing radiation to generate images of the body. Ionizing radiation is a form of radiation that has enough energy to potentially cause damage to DNA and may elevate a person's lifetime risk of developing cancer.

CT, radiography, and fluoroscopy all work on the same basic principle: An X-ray beam is passed through the body where a portion of the X-rays are either absorbed or scattered by the internal structures, and the remaining X-ray pattern is transmitted to a detector (e.g., film or a computer screen) for recording or further processing by a computer. These exams differ in their purpose:

- Radiography - a single image is recorded for later evaluation. Mammography is a special type of radiography to image the internal structures of breasts.
- Fluoroscopy - a continuous X-ray image is displayed on a monitor, allowing for real-time monitoring of a procedure or passage of a contrast agent ("dye") through the body. Fluoroscopy can result in relatively high radiation doses, especially for complex interventional procedures (such as placing stents or other devices inside the body) which require fluoroscopy be administered for a long period of time.
- CT - many X-ray images are recorded as the detector moves around the patient's body. A computer reconstructs all the individual images into cross-sectional images or "slices" of internal organs and tissues. A CT exam involves a higher radiation dose than conventional radiography because the CT image is reconstructed from many individual X-ray projections.

X-rays are a form of electromagnetic **radiation** that can pass through solid objects, including the body. X-rays penetrate different objects more or less according to their density. In medicine, X-rays are used to view images of the bones and other structures in the body. During a radiographic procedure, an x-ray beam is passed through the body. A portion of the x-rays are absorbed or scattered by the internal structure and the remaining x-ray pattern is transmitted to a detector so that an image may be recorded for later evaluation. The recoding of the pattern may occur on film or through electronic means. To obtain an X-ray image of a part of the body, a patient is positioned so the part of the body being X-rayed is between the source of the X-ray and an X-ray detector. As the X-rays pass through the body, images appear in shades of black and white, depending on the type of tissue the X-rays pass through.so the images show the parts of your body in different shades of black and white. This is because different tissues absorb different amounts of radiation. For example, the calcium in your bones makes them denser, so they absorb more radiation and appear white on X-rays. Thus when a bone is broken (fractured), the **fracture** line will appear as a dark area within the lighter bone on an X-ray film.

Less dense tissue such as muscle or fat absorbs less, and these structures appear in shades of gray on X-ray film. Air absorbs little of the X-rays, so the **lungs** and any air-filled **cavities** appear black on an X-ray film. If **pneumonia** or tumors are present in the **lungs**, they are denser than the air-filled areas of the lungs and they will appear as whiter spots on X-ray film.



Risks/Benefits

Radiography is a type of x-ray procedure, and it carries the same types of risks as other x-ray procedures. The radiation dose the patient receives varies depending on the individual procedure, but is generally less than that received during fluoroscopy and computed tomography procedures. The major risks associated with radiography are the small possibilities of developing a radiation-induced cancer or cataracts some time later in life, and causing a disturbance in the growth or development of an embryo or fetus when performed on a pregnant patient or one of childbearing age.

When an individual has a medical need, the benefit of radiography far exceeds the small cancer risk associated with the procedure. Even when radiography is medically necessary, it should use the lowest possible exposure and the minimum number of images. In most cases many of the possible risks can be reduced or eliminated with proper shielding.

X-ray using in medicine

X-ray technology is used to examine many parts of the body.

- **Fractures and infections.** In most cases, fractures and infections in bones and teeth show up clearly on X-rays.
- **Arthritis.** X-rays of your joints can reveal evidence of arthritis. X-rays taken over the years can help your doctor determine if your arthritis is worsening.
- **Dental decay.** Dentists use X-rays to check for cavities in your teeth.
- **Osteoporosis.** Special types of X-ray tests can measure your bone density.
- **Bone cancer.** X-rays can reveal bone tumors.

Chest

- **Lung infections or conditions.** Evidence of pneumonia, tuberculosis or lung cancer can show up on chest X-rays.
- **Breast cancer.** Mammography is a special type of X-ray test used to examine breast tissue.
- **Enlarged heart.** This sign of congestive heart failure shows up clearly on X-rays.
- **Blocked blood vessels.** Injecting a contrast material that contains iodine can help highlight sections of your circulatory system to make them visible on X-rays.

Abdomen

- **Digestive tract problems.** Barium, a contrast medium delivered in a drink or an enema, can help reveal problems in your digestive system.
- **Swallowed items.** If your child has swallowed something such as a key or a coin, an X-ray can show the location of that object.

How do X-rays make an image?

Main points include the following:

1. The resulting image on the X-ray detector is a two-dimensional(2D) representation of a three-dimensional (3D) structure.

2. While passing through a patient the X-ray beam is absorbed in proportion to the cube of the atomic number of the various tissues through which it passes. By convention, the greater the amount of radiation hitting a detector, the darker the image will be. Therefore, the less "dense" a material is, the more X-rays get through and the darker the image. Conversely the more "dense" a material is, the more X-rays are absorbed and the image appears whiter. Materials of low "density" appear darker than those of high "density".

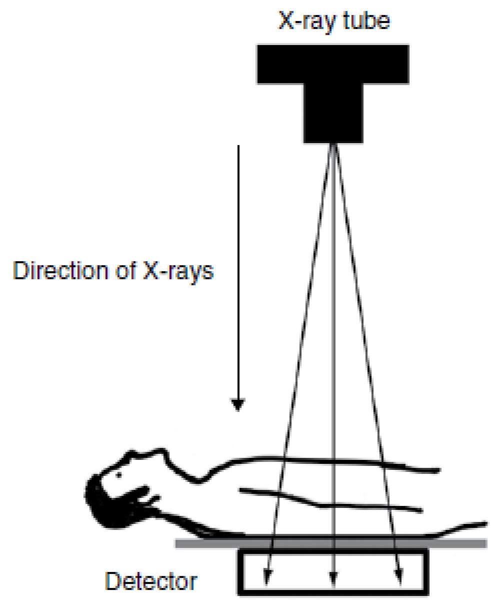
3. Structures can only be seen if there is sufficient contrast with surrounding tissues (contrast is the difference in absorption between one tissue and another). An x-ray examination creates images of your internal organs or bones to help diagnose conditions or injuries. A special machine emits (puts out) a small amount of ionizing radiation. This radiation passes through your body and is captured on a special device to produce the image. The dose of radiation you will receive depends on the area of your body being examined. Smaller areas such as the hand receive a lesser dose compared to a larger area such as the spine.

How do medical x-rays work?

as we mentioned it in first part of x-ray to create a radiograph, a patient is positioned so that the part of the body being imaged is located between an x-ray source and an x-ray detector. When the machine is turned on, x-rays travel through the body and are absorbed in different amounts by different tissues, depending on the radiological density of the tissues they pass through. Radiological density is determined by both the density and the atomic number (the number of protons in an atom's nucleus) of the materials being imaged. For example, structures such as bone contain calcium, which has a higher atomic number than most tissues. Because of this property, bones readily absorb x-rays and, thus, produce high contrast on the x-ray detector. As a result, bony structures appear whiter than other tissues against the black background of a radiograph. Conversely, x-rays travel more easily through less radiologically dense tissues such as fat and muscle, as well as through air-filled cavities such as the lungs. These structures are displayed in shades of gray on a radiograph.

Abdominal X-ray views

The patient lies supine (on their back). The X-ray tube is positioned overhead in front of the patient, so the X-rays pass in the anterior–posterior (AP) direction. The patient is asked to hold their breath (so that breathing movement will not make the image blurry) and the X-ray is taken.



Anterior–posterior (AP) supine abdominal X-ray.

Chest X - ray (CXR) views

PA projection

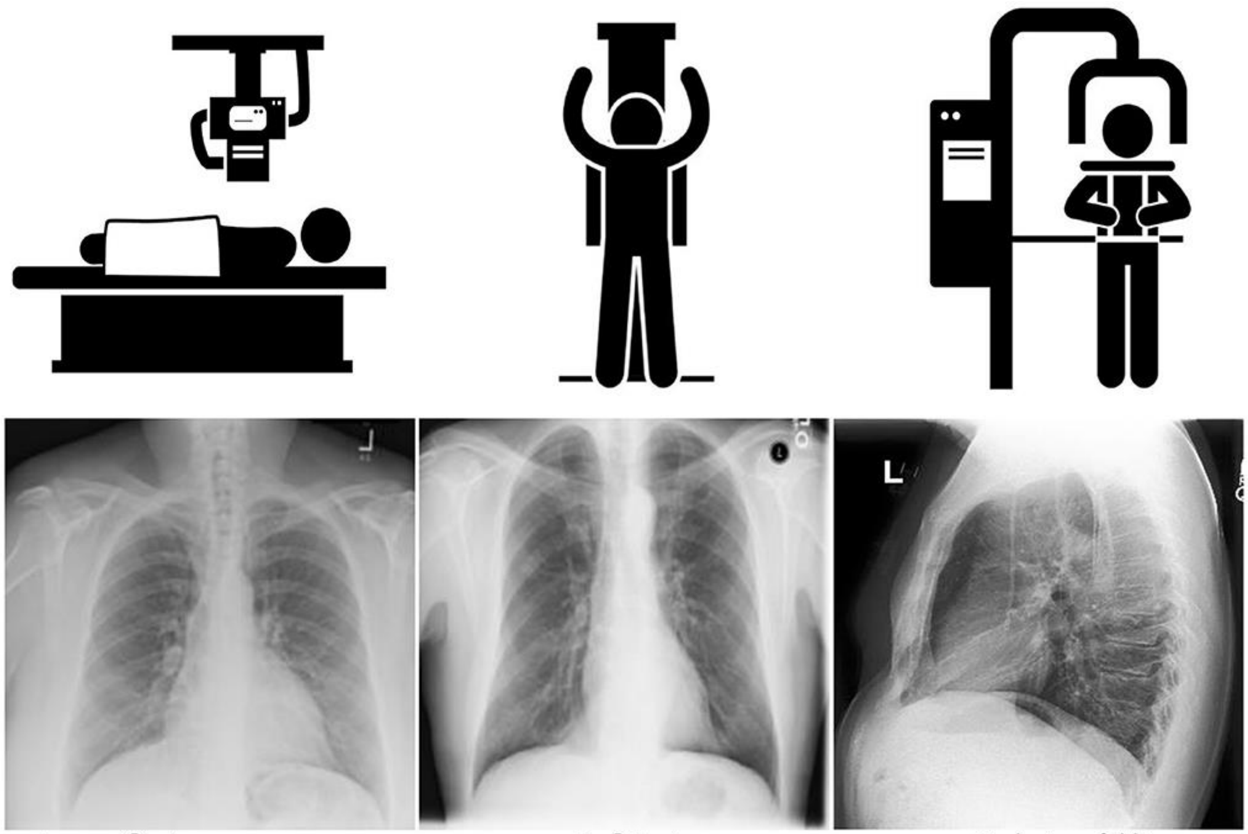
- the poster anterior (PA) view is the standard frontal chest projection
- the x-ray beam traverses the patient from posterior to anterior
- it is performed standing and in full inspiration with the patient hugging the detector to pull the scapulae laterally
- it is the best general radiographic technique to examine the lungs, bony thoracic cavity, mediastinum and great vessels
- advantages: technically excellent visualization of the mediastinum and lungs, with accurate assessment of heart size
- disadvantages: patient must be able to stand erect

AP projection

- the anteroposterior (AP) erect view is an alternative frontal projection to the PA projection with the beam traversing the patient from anterior to posterior
- it can be performed with the patient sitting up on the bed and even performed outside the radiology department using a mobile x-ray unit

- advantages: more convenient for intubated and sick patients who will not be able to stand for a PA projection
- disadvantages: mediastinal structures may appear magnified as the heart is further away from the detector, often poorly inspired, more likely to be rotated and to create skin folds, scapulae often cover some of the lungs
- a AP supine view is a further alternative frontal projection technique often used in trauma patients, or patients who can't sit up
- the supine position results in physiological widening of the cardio mediastinal outline including superior mediastinum, as well as congestion of the pulmonary veins with upper lobe venous diversion

• **Lateral CXR** is used to give further views of the lungs and heart, and more details on the anatomical location of lesions. It is rarely performed now as CT gives more information.



A AP view B PA view C Lateral View

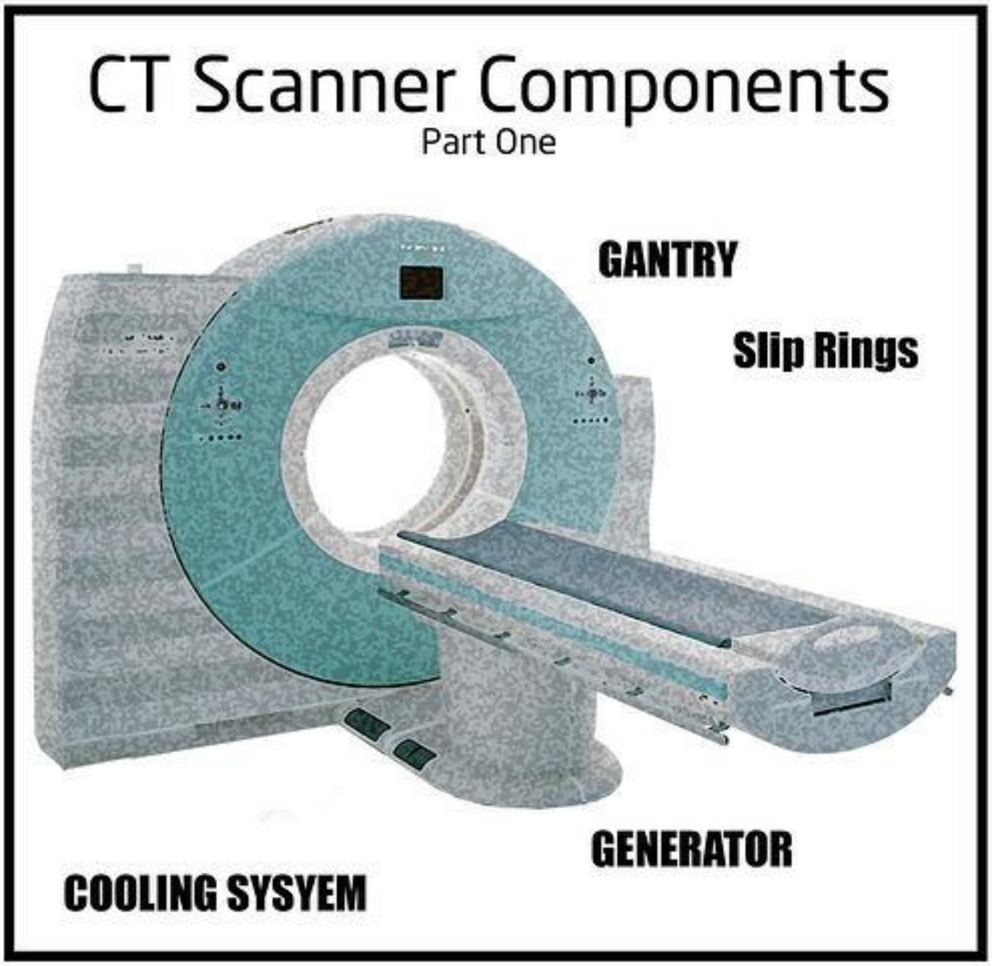
CT (Computed Tomography) Scan

WHAT IS A CT SCAN?

Medical professionals use computed tomography, also known as CT scan, to examine structures inside your body. A CT scan uses X-rays and computers to produce images of a cross-section of your body. It takes pictures that show very thin “slices” of your bones, muscles, organs and blood vessels so that healthcare providers can see your body in great detail.

CT scans have a doughnut-shaped tube that rotates the X-ray 360 degrees around you. The data captured provides a detailed 3D view of the inside of your body. A CT scanner emits a series of narrow beams through the human body as it moves through an arc. This is different from an X-ray machine, which sends just one radiation beam. The CT scan produces a more detailed final picture than an X-ray image. The CT scanner’s X-ray detector can see hundreds of different levels of density. It can see tissues within a solid organ. scanners are composed of three important elements: An X-ray tube, a gantry with a ring of X-ray sensitive detectors, and a computer. In this method, images are created using the same physics principles as in conventional radiography. Inside a vacuum tube, electrons produced by a heated cathode are directed toward a rotating anode, which converts electron energy into X-rays and dissipates heat. These X-rays pass through filters and small lead doors (collimators) creating a beam that is aimed at the anatomical area to be studied. The X-ray tube output, or exposure, is controlled by values for m amp or current, peak kilovolts (kVp) or voltage, and exposure time.

The patient is placed in a tubular gantry surrounded by a ring of X-ray sensitive detectors localized opposite to the X-ray tube. When the rotating X-ray beam enters the body and contacts tissues (organs) of different density, the beam is variably absorbed and undergoes attenuation (decrease in energy and number of photons), which is recorded by the X-ray detectors upon its ultimate exit from the body. The detectors convert the exiting beam into amplified electrical pulses that vary in intensity according to the residual beam strength. The acquired dataset is sent to a computer that analyzes the location and density information and generates axial, cross-sectional images of internal structures of the body.



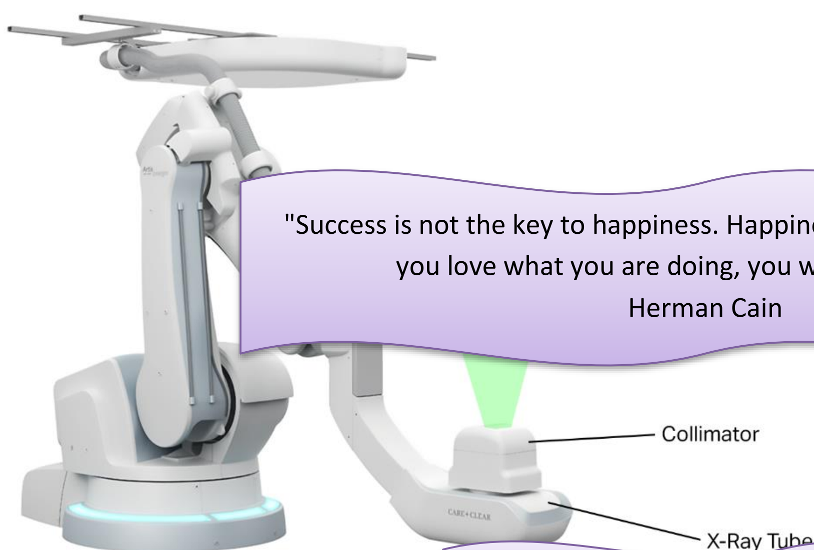
This data is transmitted to a computer, which builds up a 3-D cross-sectional picture of the part of the body and displays it on the screen. Sometimes, a contrast dye is used because it can help show certain structures more clearly. For instance, if a 3-D image of the abdomen is required, the patient may have to drink a barium meal. The barium appears white on the scan as it travels through the digestive system. If blood vessel images are the target, a contrast agent will be injected into the veins.

WHAT DOES A CT SCAN SHOW?

Soft tissues ,the pelvis ,blood vessels ,lungs ,brain ,abdomen and bones CT is often the preferred way of diagnosing many cancers, such as liver, lung, and pancreatic cancers. The image allows a doctor to confirm the presence and location of a tumor, its size, and how much it has affected nearby tissue. A scan of the head can provide important information about the brain, for instance, if there is any bleeding, swelling of the arteries, or a tumor. It can also detect a tumor in the abdomen, and any swelling or inflammation in nearby internal organs.

HOW A CT SYSTEM WORKS?

- A motorized table moves the patient through a circular opening in the CT imaging system.
- While the patient is inside the opening, an X-ray source and a detector assembly within the system rotate around the patient. A single rotation typically takes a second or less. During rotation the X-ray source produces a narrow, fan-shaped beam of X-rays that passes through a section of the patient's body.
- Detectors in rows opposite the X-ray source register the X-rays that pass through the patient's body as a snapshot in the process of creating an image. Many different "snapshots" (at many angles through the patient) are collected during one complete rotation.
- For each rotation of the X-ray source and detector assembly, the image data are sent to a computer to reconstruct all of the individual "snapshots" into one or multiple cross-sectional images (slices) of the internal organs and tissues.



"Success is not the key to happiness. Happiness is the key to success. If you love what you are doing, you will be successful"
Herman Cain

"It's never too late to be what you might have been.
-George Eliot

Fluoroscopy

What is fluoroscopy?

Fluoroscopy is a type of x-ray that shows organs, tissues, or other internal structures moving in real time. Standard x-rays are like still photographs. Fluoroscopy is like a video. It shows your body systems in action. These include the cardiovascular (heart and blood vessels), digestive, and reproductive systems. Fluoroscopy allows your health care provider to watch your organs or structures as they function, such as your heart beating, lungs inflating, or intestines moving food. The procedure can help your provider evaluate and diagnose a variety of conditions.

What is it used for?

Fluoroscopy is used in many types of imaging procedures. It can be used to guide your provider during a procedure visually or to help diagnose a health condition. Some of the most common uses of fluoroscopy include:

- **Barium swallow or barium enema.** In these procedures, fluoroscopy shows the movement of the gastrointestinal (digestive) tract.
- **Cardiac catheterization.** In this procedure, fluoroscopy shows blood flowing through the arteries. It is used to diagnose and treat some heart diseases.
- **Placement of a catheter or stent inside the body.** Catheters are thin, hollow tubes. They are used to get fluids into the body or to drain excess fluids from the body. Stents are devices that help open narrow or blocked blood vessels. Fluoroscopy helps ensure the proper placement of these devices.
- **Guidance in orthopedic surgery.** A surgeon may use fluoroscopy may be used by a surgeon to help guide procedures such as joint replacement and fracture (broken bone) repair.

Overview of a fluoroscopy system

x-ray generator

x-ray tube, including filters and collimation

patient table

image intensifier: converts x-rays emerging from the patient into an optical image optical distributor: used to couple the output image from the image intensifier to receiving devices:

video camera: converts the image into an electronic signal, which can be fed into the image display/record device

spot-film camera recording static images onto film, which may incorporate a film changer (radiography and fluoroscopy (R&F) system)

cine camera: to record a sequence of images onto a roll of film/digital medium

image displaying/recording device

video monitor: for immediate display of image (video fluoroscopy)

videotape recorder: for storage and subsequent replay

computer: for digital image processing, analysis and storage (digital fluorography), e.g. digital subtraction angiography (DSA).

What is the difference between a CT scan and fluoroscopy?

Computed Tomography (CT) scans and fluoroscopy are two different imaging techniques used to diagnose medical conditions. A CT scan is a type of imaging that uses X-rays to create detailed 3D images of the body, while fluoroscopy is an imaging technique that uses X-rays to create real-time 2D images of the body. The main difference between CT scan and fluoroscopy is that CT is fully volumetric and better for low contrast imaging, such as imaging blood in the brain during stroke triage or changes in the gray and white matter which occur hours to days after a stroke. Modern CT scanners also do have real-time fluoroscopic imaging modes. However, traditional fluoroscopy has a higher frame rate and higher spatial resolution than CT and there are many clinical tasks where the higher frame-rate and spatial resolution of an x-ray fluoroscopy system outweigh the benefits of CT

What Is the Difference Between an X-Ray and a CT Scan?

While the difference between CT scan and x-ray is minor, it's also significant. X-rays use a single beam of radiation to produce an image. A CT scan uses many X-ray beams at different angles around the body, which are then combined by a computer into one image. Doctors use x-rays to detect dislocations and fractures of bones as well as detect cancers and pneumonia. However, CT scans are a type of advanced x-ray devices doctors use for diagnosing internal organ injuries, using x-ray images of the structure and a computer.

X-ray machines in some cases fail to diagnose problems with muscle damage, soft tissues or other body organs, but with the CT scan, it's entirely possible. x-ray images are in 2D, while CT scan images are 3D. The CT scanning machine rotates on an axis and takes various 2D images of an individual's body from multiple angles. Then, the computer will place all the cross-sectional images together on its screen, resulting in a 3D image of the body's inside, revealing the presence of injury or disease to the doctor.

A CT scan employs a higher level of radiation in comparison to an X-Ray. In order to capture 3-dimensional views of the structures, larger doses of radiation are used. For example, if we take the example of **chest X-ray vs chest CT scan**, the former delivers 0.1 mSV, while the latter delivers 7 mSV.

positron emission tomography (PET)

What is positron emission tomography (PET)?

Positron emission tomography (PET) is a type of nuclear medicine procedure that measures metabolic activity of the cells of body tissues. PET is actually a combination of nuclear medicine and biochemical analysis. Used mostly in patients with brain or heart conditions and cancer, PET helps to visualize the biochemical changes taking place in the body, such as the metabolism (the process by which cells change food into energy after food is digested and absorbed into the blood) A PET scan measures important body functions, such as blood flow, oxygen use, and sugar (glucose) metabolism, to help doctors evaluate how well organs and tissues are functioning

PET differs from other nuclear medicine examinations in that PET detects metabolism within body tissues, whereas other types of nuclear medicine examinations detect the amount of a radioactive substance collected in body tissue in a certain location to examine the tissue's function.

Since PET is a type of nuclear medicine procedure, this means that a tiny amount of a radioactive substance, called a radionuclide or radioactive tracer, is used during the procedure to assist in the examination of the tissue under study. Specifically, PET studies evaluate the metabolism of a particular organ or tissue, so that information about the physiology (functionality) and anatomy (structure) of the organ or tissue is evaluated, as well as its biochemical properties. Thus, PET may detect biochemical changes in an organ or tissue that can identify the onset of a disease process before anatomical changes related to the disease can be seen with other imaging processes such as computed tomography (CT) or magnetic resonance imaging (MRI).

PET is most often used by oncologists (doctors specializing in cancer treatment), neurologists and neurosurgeons (doctors specializing in treatment and surgery of the brain and nervous system), and cardiologists (doctors specializing in the treatment of the heart). However, as advances in PET technologies continue, this procedure is beginning to be used more widely in other areas.

The scan uses a special dye containing radioactive tracers. These tracers are either swallowed, inhaled, or injected into a vein in your arm depending on what part of the body is being examined. Certain organs and tissues then absorb the tracer. When detected by a PET scanner, the tracers help your doctor to see how well your organs and tissues are working. The tracer will collect in areas of higher chemical activity, which is helpful because certain tissues of the body, and certain diseases, have a higher level of chemical activity. These areas of disease will show up as bright spots on the PET scan. The PET scan can measure blood flow, oxygen use, how your body uses sugar, and much more.

How does PET work?

Physical basis of (PET) is based on the physical properties of isotopes radioactive forms of simple atoms emitting positrons when they decay. In PET centers, isotopes are obtained by means of cyclotrons. Simple atoms are arranged into more complex molecules like molecules of oxygen, water, glucose, etc.

PET works by using a scanning device (a machine with a large hole at its center) to detect photons (subatomic particles) emitted by a radionuclide in the organ or tissue being examined.

The radionuclides used in PET scans are made by attaching a radioactive atom to chemical substances that are used naturally by the particular organ or tissue during its metabolic process. For example, in PET scans of the brain, a radioactive atom is applied to glucose (blood sugar) to create a radionuclide called fluorodeoxyglucose (FDG), because the brain uses glucose for its metabolism. FDG is widely used in PET scanning. Fludeoxyglucose is a radioactive tracer that acts as a glucose analog and is used for diagnostic purposes in conjunction with positron-emitting tomography (PET) to localize the tissues with altered glucose metabolism. It does not have therapeutic use. FDG is a glucose analog that tends to accumulate in the tissue with high glucose demand, like tumors and inflammatory cells.

Other substances may be used for PET scanning, depending on the purpose of the scan. If blood flow and perfusion of an organ or tissue is of interest, the radionuclide may be a type of radioactive oxygen, carbon, nitrogen, or gallium.

The radionuclide is administered into a vein through an intravenous (IV) line. Next, the PET scanner slowly moves over the part of the body being examined. Positrons are emitted by the breakdown of the radionuclide. Gamma rays are created during the emission of positrons, and the scanner then detects the gamma rays. A computer analyzes the gamma rays and uses the information to create an image map of the organ or tissue being studied. The amount of the radionuclide collected in the tissue affects how brightly the tissue appears on the image, and indicates the level of organ or tissue function.

Why is PET performed?

PET scans may be used to evaluate organs and/or tissues for the presence of disease or other conditions. PET may also be used to evaluate the function of organs, such as the heart or brain. The most common use of PET is in the detection of cancer and the evaluation of cancer treatment.

More specific reasons for PET scans include, but are not limited to, the following:

- To diagnose dementias (conditions that involve deterioration of mental function), such as Alzheimer's disease, as well as other neurological conditions such as:
  - Parkinson's disease. A progressive disease of the nervous system in which a fine tremor, muscle weakness, and a peculiar type of gait are seen.
  - Epilepsy. A brain disorder involving recurrent seizures.
  - stroke
- To locate the specific surgical site prior to surgical procedures of the brain
- To evaluate the brain after trauma to detect hematoma (blood clot), bleeding, and/or perfusion (blood and oxygen flow) of the brain tissue
- To detect the spread of cancer to other parts of the body from the original cancer site
- To evaluate the effectiveness of cancer treatment
- To evaluate the perfusion (blood flow) to the myocardium (heart muscle) as an aid in determining the usefulness of a therapeutic procedure to improve blood flow to the myocardium
- To further identify lung lesions or masses detected on chest X-ray and/or chest CT

- To assist in the management and treatment of lung cancer by staging lesions and following the progress of lesions after treatment
- To detect recurrence of tumors earlier than with other diagnostic modalities