Molecular Imaging Techniques

Electron Microscopy

TEM – Transmission Electron Microscopy

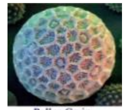
(Cryo EM)

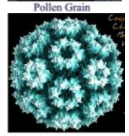
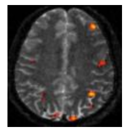
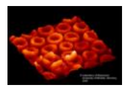
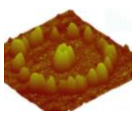
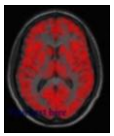
SEM – Scanning Electron Microscopy

STM / AFM – Atomic Force Microsopy

Medical Imaging Methods

(CAT / PET / MRI / Ultrasound)




X-ray Radiography

Bone absorbs X-rays particularly well, soft tissue has a lower density and absorbs fewer X-rays. Result is the familiar good contrast seen in X-ray images, with bones shown as clearly defined white areas and darker areas of tissue.

Very suitable for scans of **bones** and tissue dense in calcium such as in **dental images** and detection of **bone fractures**, study of the organs in the abdomen such as the liver and bladder; chest radiography for **pneumonia** or **lung cancer** and **mammography** for breast cancer.

X-ray fluoroscopy is used to detect a number of diseases associated with the stomach and intestine, genitals and urinary tract.

http://www.medicalradiation.com/types-of-medical-imaging/

Fluoroscopy:

Fluoroscopy is used where real-time examination of the patient's body is required. positioning of orthopedic implants during surgery, catheters and pacemakers, viewing the movement of contrast agents, such as barium, through the body and studying the movement of parts of the body.

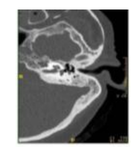
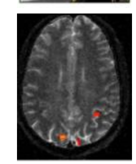
Barium products, taken orally, are used for examining the gastro-intestinal system. Fluoroscopy is used in many types of examinations and procedures, e.g. barium X-rays and enemas to view movement through the gastro-intestinal tract.

Medical Imaging - Radiology

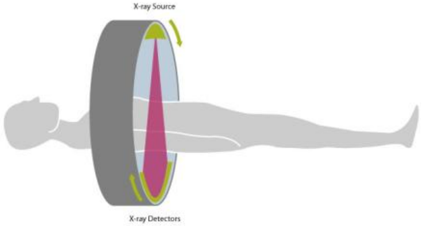
CAT (or CT) - Computerized Axial Tomography
A computerized assembly of several x-ray images taken at different angles.

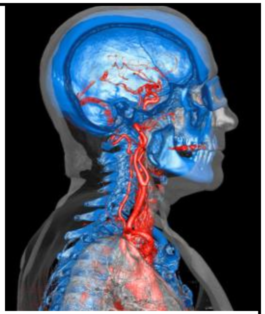
MRI (or NMRI) - Magnetic resonance imaging (MRI) produces high quality images of the inside of the human body. MRI is a noninvasive imaging technique that does not use x-rays. The fluid contrast between structures in the brain can then be visualized.

PET - positron emission tomography (PET); PET produces images of metabolic activity as opposed to images of the body's physical properties. A small amount of radioactivity in a metabolite is introduced into the body. These are concentrated and processed by tissues as part of their normal function. The source of the radiation in the body pinpoints the location of the metabolites.


CAT scans

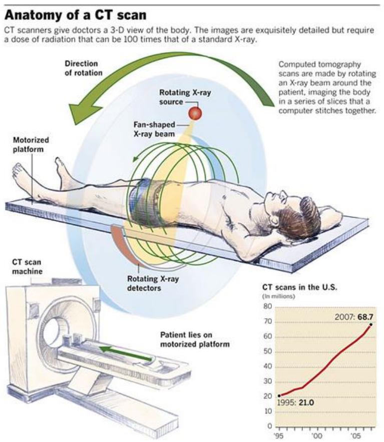




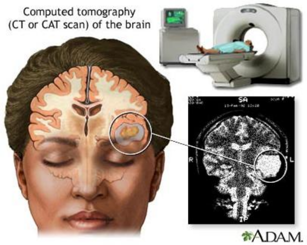
The most prominent part of a CT scanner is the gantry – a circular, rotating frame with an X-ray tube mounted on one side and a detector on the opposite side. A fan-shaped beam of X-rays is created as the rotating frame spins the X-ray tube and detector around the patient. As the scanner rotates, several thousand images are taken in one rotation resulting in one complete cross-sectional image of the body. Built on these data, it is possible to create a 3D visualization and views from different angles.

For some CT scans, a special contrast agent is injected into a vein before the scan as this allows for further assessment of the organs and vessels.

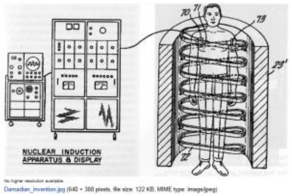
CT Scan



During a computerized tomography (CT) scan, a thin x-ray beam rotates around an area of the body, generating a 3-D image of the internal structures



MRI Scan



The first MRI of a human body was done on a graduate student of Dr. Raymond Damadian July 3, 1977. It took almost five hours to produce one image, and that original machine, named the "Indomitable," is now owned by the Smithsonian Institution.
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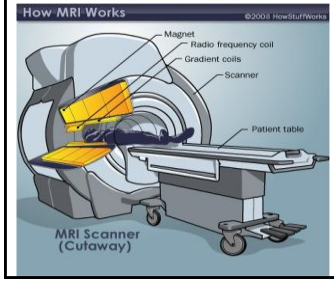
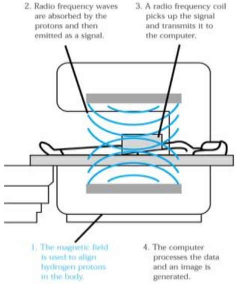
Imagine each hydrogen atom as a tiny magnet. In the MRI machine, they all line up. When the RF pulse disappears, they go back to their normal positions, releasing energy, which the system uses to make an image.

Gradient magnets are small magnets that change the field within an MRI system. When turned on and off very rapidly, they essentially change the focus of the overall field. This enables the MRI system to choose exactly where in the body to acquire an image.

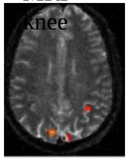
MRI Image Gallery

Lester Lefkowitz/Photographer's Choice/Getty Images
Intro the abyss. See more MRI pictures.

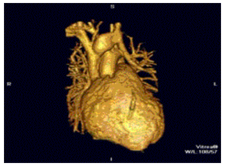




MRI - knee



MRI – brain



MR angiogram in congenital heart disease

Which is better - a CT scan or an MRI?

The machines look similar, BUT what occurs inside these "donut holes" is quite different.

CT scanner: sends X-ray beams through the body*
can "see" different levels of density and tissues inside a solid organ
head (brain and its vessels, eyes, inner ear, and sinuses)
chest (heart and lungs)
skeletal system (neck, shoulders and spine)
pelvis and hips, reproductive systems, bladder and gastrointestinal tract

→ muscle or bone disorder, look for tumors, a fracture or a blood clot.

MRI scanner: use powerful magnetic fields and radio frequency pulses
produce detailed pictures of organs, **soft tissues**, bone
tumors, stroke, aneurysm, breast & lung cancer, blood flow

→ differences between normal and abnormal tissue is often clearer on an MRI image than a CT. Good for seeing tendons, ligaments, spinal cord

** The average CT scan today exposes patients to less radiation than what airline passengers receive on long flights.*

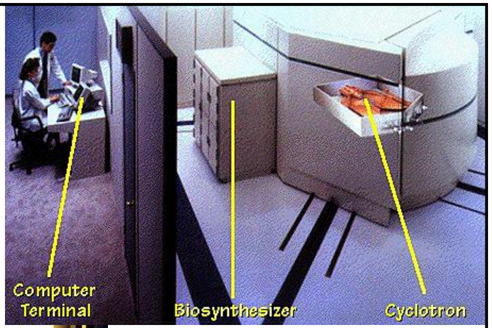
Molecular Imaging:

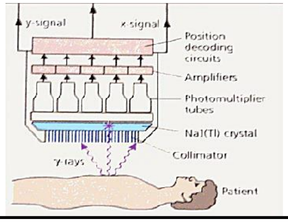
Molecular imaging allows biological **processes taking place in the body to be viewed at a cellular and molecular level**. This breakthrough enables doctors to identify disease in its earliest stages, often well before they would be seen on **CT** or **MRI** images and would otherwise require invasive surgery or biopsy – the removal of tissue for examination under the microscope.

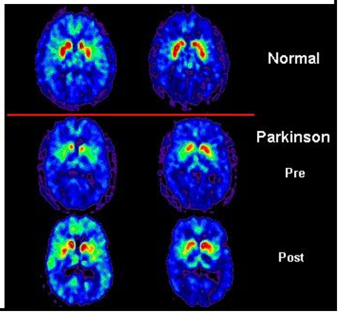
The radiopharmaceutical is either injected into a vein, swallowed or inhaled as a gas. The drug accumulates in the organ or area of the body being examined, where it gives off energy in the form of gamma rays. This energy is detected by **positron emission tomography (PET)** or **single photo emission (SPECT)** scanner .

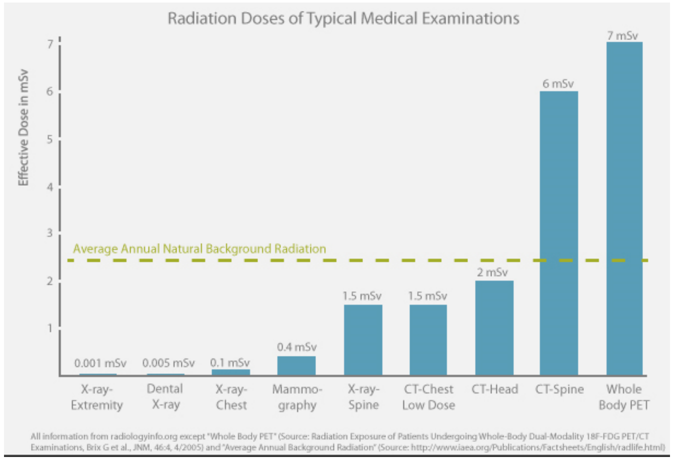
Molecular imaging procedures are used to diagnose and manage the treatment of **brain and bone disorders**, cancer, gastrointestinal disorders, **heart and kidney diseases, lung and thyroid disorders**.

PET Scans









Combined Modalities:

Molecular imaging offers physicians a unique insight into the workings of the human body at a cellular and molecular level, enabling them to diagnose and to characterize potential disease at a very early stage. **To correlate the biological processes with anatomical location in the body, molecular imaging devices are integrated with CT and MRI scanners**. Computers are used to fuse the biological and anatomical images together to help doctors make better diagnostic and therapeutic decisions.

Ultrasonography:

Introduction to Ultrasound Imaging

Ultrasound scanners - a form of 'medical' Sonar

SONAR = Sound Navigation and Ranging

RADAR = Radio Detection and Ranging

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1877 - Lord Rayleigh – "The Theory of Sound" – sound waves

1912 - Underwater navigation - submarines WWI, Titanic sank

1935 - First practical RADAR using electromagnetic waves

1940s – Ultrasound therapy: **arthritis**, **craniotomies**

1952 – John Wild – "Application of Echo-Ranging Techniques to the Determination of Structure of Biological Tissues"

1958 – "Investigation of Abdominal Masses by Pulsed Ultrasound" (an important early paper on medical diagnostic uses of ultrasound)

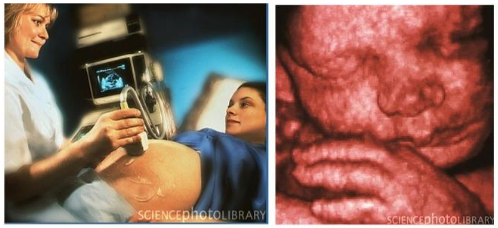
What are Obstetric Ultrasound Scans?

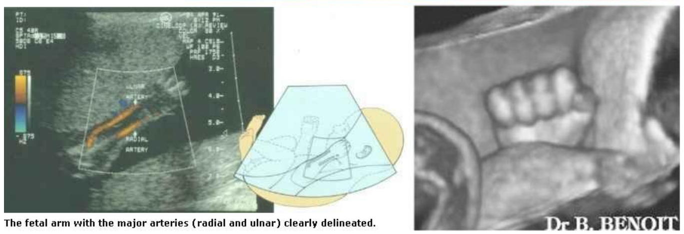
Obstetric Ultrasound is the use of ultrasound scans in pregnancy. Since the late 1950's ultrasonography has become a very useful diagnostic tool in Obstetrics. Currently used real-time scanners using very high frequency sound waves of between 3.5 to 7.0 megahertz (i.e. 3.5 to 7 million cycles per second) can provide a continuous picture of the moving fetus can be depicted on a monitor screen. and growth in the fetus. The conducting gel is non-staining but may feel slightly cold and wet. There is no sensation at all from the ultrasound waves.

Transducer (probe) on the abdomen

3-D scan of fetal face

Ultrasound
and
3D Ultrasound





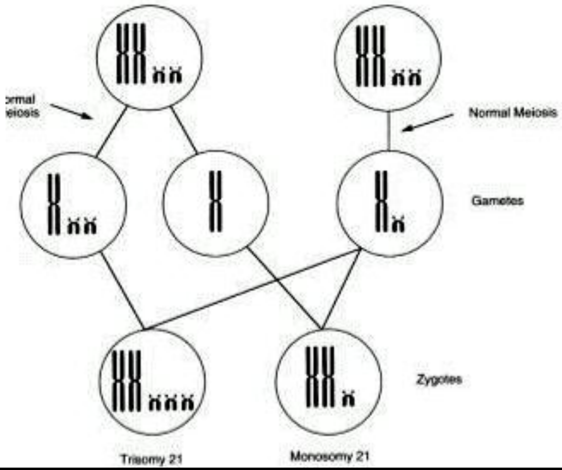
The fetal arm with the major arteries (radial and ulnar) clearly delineated.

Inherited Abnormalities

	/10^3 live births
Down's Syndrome*	1.3
Cystic Fibrosis	0.4
Familial Hypercholesterolaemia	2.0
PKU	0.1
Hypothyroidism	0.25

- First described **1866 - JLH Down**
- Clinical Features
  - Average life expectancy 30 years
  - Characteristic phenotype
  - Learning disability (IQ 20-60)
  - Developmental delay / Hypotonia
  - Delayed puberty / Early menopause

Downs Syndrome - Trisomy 21

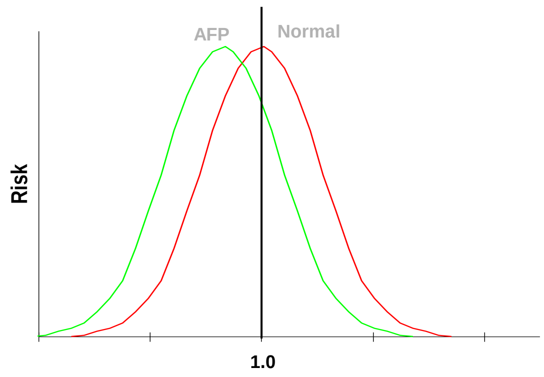


Screening Tests: Screening tests are used to look for potential problems and to identify those who **are at high risk of** having a baby with a genetic disorder.

The triple screen and the alpha-fetoprotein plus, and more recently, the quad test measure the **amounts of certain** hormones and proteins in the blood including alpha-fetoprotein, human chorionic gonadotropin, **unconjugated estriol and** inhibin. The results of these tests together with the woman's age, will provide an estimate of her **risk of having a child** with Down syndrome. These tests are usually performed between the fourteenth and sixteenth **week of gestation.** Approximately 60-80% of fetuses with Down syndrome can be identified prenatally by considering **the mother's age and** employing these screening tests.

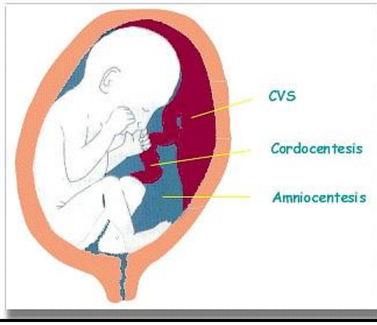
In addition ultrasound examinations are almost always performed. During an ultrasound examination **the physician looks** for "markers", such as a thickening of the skin at the back of the neck (nuchal fold), bright spots **on the kidneys or heart,** short arms or legs, reduced head size, congenital heart disease, and gastrointestinal problems. If **any of these "markers"** are observed, diagnostic testing is generally recommended.

Theoretical AFP Distributions



Non-invasive procedure

Amount of fluid behind the neck of the fetus (Nuchal translucency) scan



Three invasive procedures

chromosomal abnormality

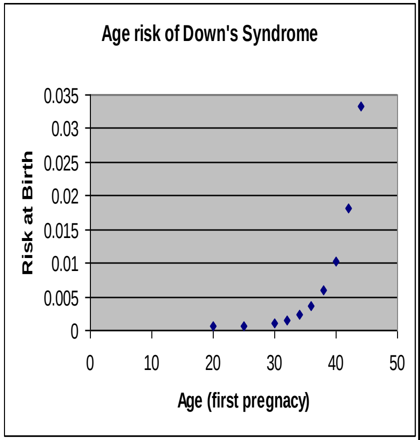
Chorion villus (placenta) sampling (11-14 wks)

Amniocentesis (>15 wks)

Cordocentesis (>20 wks)

Down's Syndrome (Trisomy 21)

MATERNAL AGE	RISK AT BIRTH
20	1/1527
25	1/1352
30	1/895
32	1/659
34	1/446
36	1/280
38	1/167
40	1/97
42	1/55
44	1/30



http://www.fetalmedicine.ac.uk/antenatal.htm

THE END

Good Luck on EXAM-3