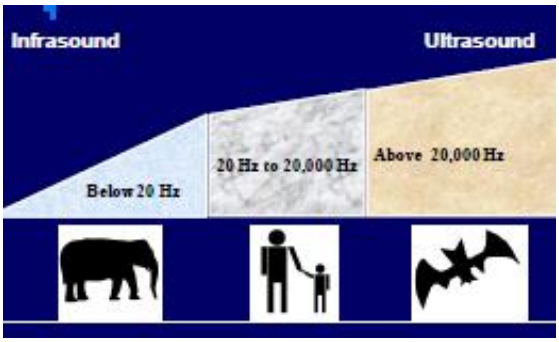
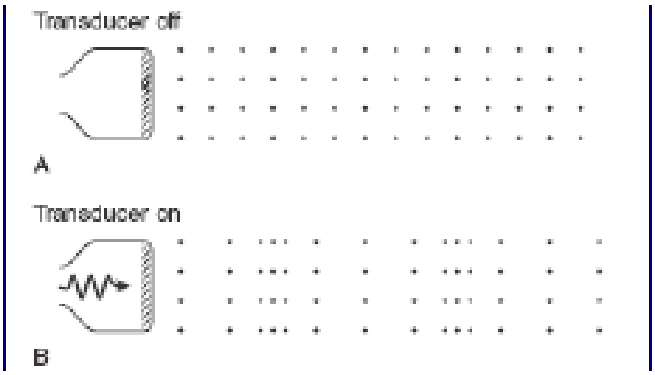
Introduction To Ultrasonography

- Ultrasound, as the name implies, is high-frequency sound.
- Sound waves travel through a medium by causing local displacement of particles within the medium; however, there is no overall movement of the medium.



- Ultrasound is a longitudinal wave, as the displacement of the particles within the medium is in the same direction as that in which the wave is travelling.
- The position of the particles within the medium will change as a sound wave passes through it, causing local periodic displacement



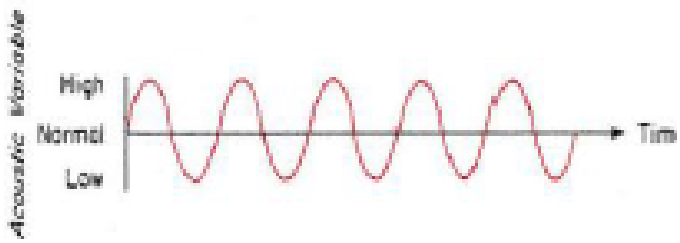
Piezoelectric Effect

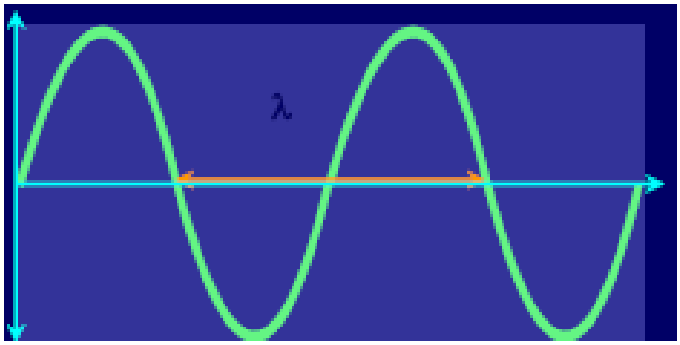
- The term transducer simply means a device thatconverts one form of energy into another.
- In the case of an ultrasound transducer, thisconversion is from electrical energy tomechanical vibration. The piezoelectric effect isthe method by which most medical ultrasound is generated.

Wavelength & frequency
Propagation.
Acoustic impedance.
Attenuation.
Reflection

Wavelength & frequency

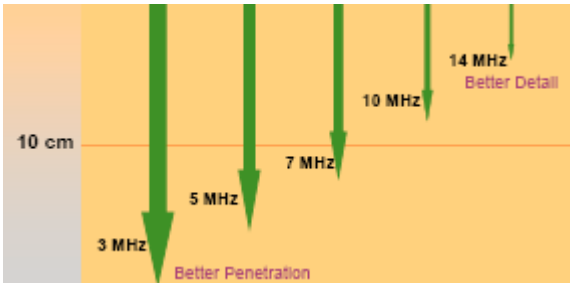
The wavelength is the distance between consecutive compressions or rarefaction, or between any two points that repeat.





Wavelength & frequency

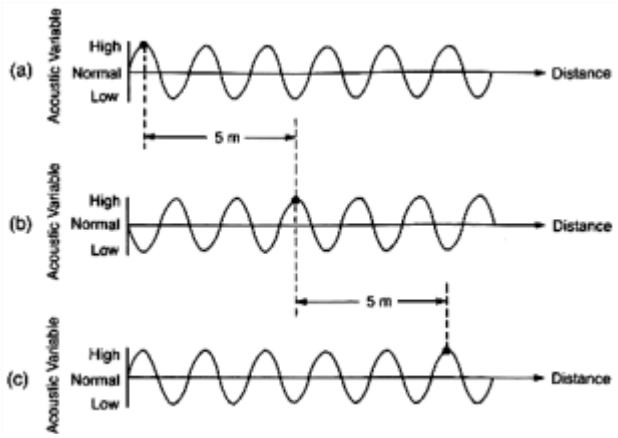
- The higher the frequency the shorter is the wavelength the better the resolving of small structures.



Propagation

- Sound travels through different media at different speeds (e.g., sound travels faster through water than it does through air)
- The speed of sound through a material depends on both the density and the compressibility of the material.
- The more dense and the more compressible the material, the slower the wave will travel through it.

- The propagation speed (or velocity) is the distance travelled per unit time (second) of the energy pulse.



Propagation

Velocity = frequency x wavelength

Material	Velocity (m/s)
Water	1480
Blood	1570
Fat	1500
Muscle	1580
Soft Tissue	***1540***
Air	348
Bone	3360

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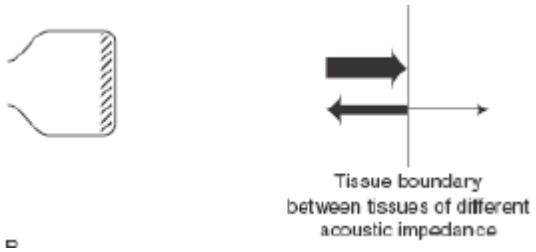
Acoustic impedance

- The creation of an ultrasound image depends on the way in which ultrasound energy interacts with the tissue as it passes through the body.
- When an ultrasound wave meets a large smooth interface between two different media, some of the energy will be reflected back, and this is known as specular reflection. The relative proportions of the energy reflected and transmitted depend on the change in the impedance between the two materials
- The acoustic impedance of a medium is the impedance (similar to resistance) the material offers against the passage of the sound wave through it and depends on the density and compressibility of the medium.
- The greater the change in the acoustic impedance, the greater the proportion of the ultrasound that is reflected.



- Large difference in acoustic impedance between soft tissue and bone, or between soft tissue and air, and such interfaces will produce large reflections. This is the reason why ultrasound cannot be used to image beyond lung or bone as only a small proportion of the ultrasound is transmitted.

Attenuation

- As sound travels through tissue, there is loss of signal due to:
- Absorption
- Scattering
- refraction
- Causes decrease of the returning signal with increase of the distance of the target.
- Sound wave travels through the substance but loses energy

Refraction

Sound wave bends as it hits an interface at an oblique angle

Scatter

Sound wave dispersed in all directions

Attenuation

- Attenuation increase in proportion to the frequency and usually expressed in db/cm/MHz.
- It affects both the transmitted pulse and received echo so the effect is doubled.
- Higher frequencies being attenuated more quickly than lower frequencies.
- This is why higher ultrasound frequencies penetrate tissue less effectively than lower ultrasound frequencies and can only be used for imaging superficial structures

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Reflection

- Sound wave bounces back towards the probe
- The amount of sound wave reflection is dependent on the "resistance" of the substance it is trying to pass through
- Resistance = ↑Reflection back to probe
  =↑ Energy detected by probe
  = Whiter image
- Resistance = ↓Reflection back to probe
  =↓Energy detected by probe
  = Darker image

US image

High resistance (WHITE on the ultrasound)

Bone/Stone

Liver/Spleen/Kidney

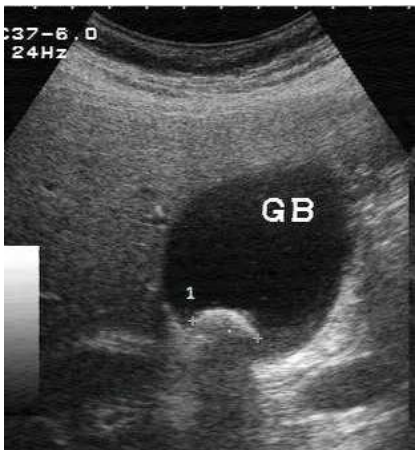
Blood/Urine

Low resistance (BLACK on the ultrasound)

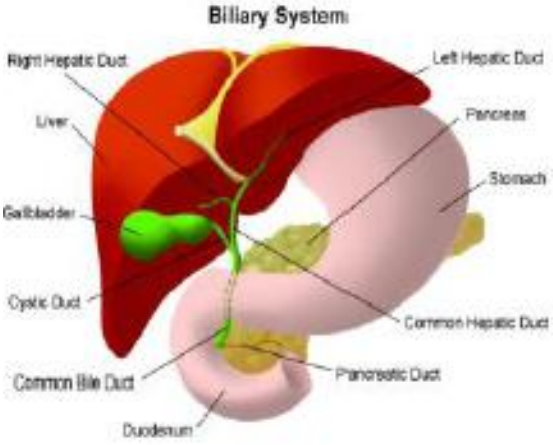
False images caused by unique interactions between the sound wave and structures in the body

- Shadowing
- Enhancement

- Ultrasound wave hits a substance that causes near total reflection
- Everything behind the blocking structure appears black (since no energy is getting through)
- Common causes
- Bone ,gallstones, kidney stones, calcification
- Ultrasound waves pass through an area of low resistance with little attenuation (ie little loss of energy)
- As it hits a denser substance behind it, the energy is dispersed and "lights up" the deeper tissues
- Common causes Cyst, Gallbladder, Bladder

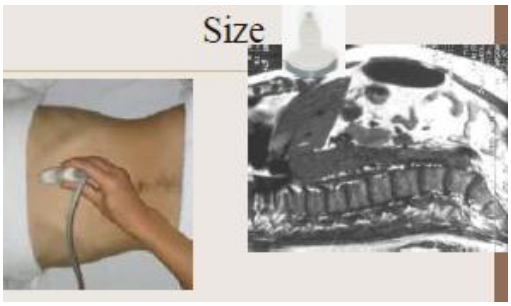


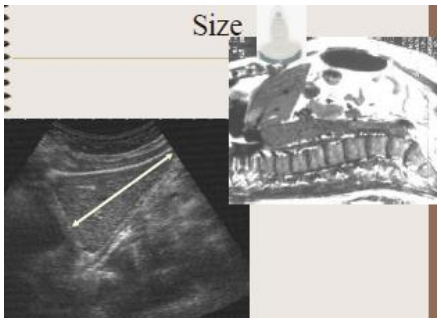
The liver

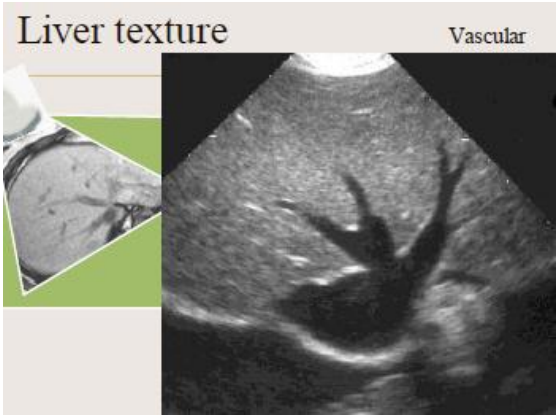


The Liver

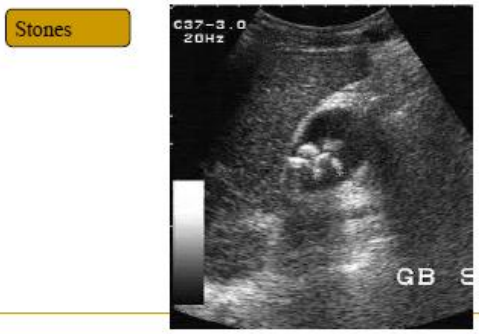
1.Size .
2.Texture.
3.Hepatic vasculature . (portal vein & hepatic veins).
4.Intrahepatic biliary radicles.







Gall Bladder



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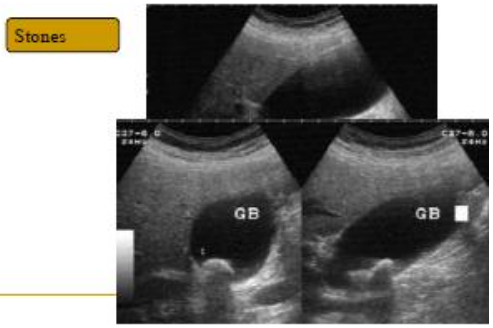

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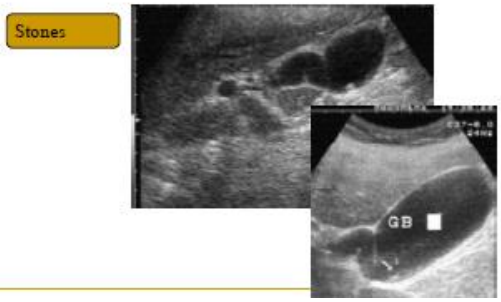
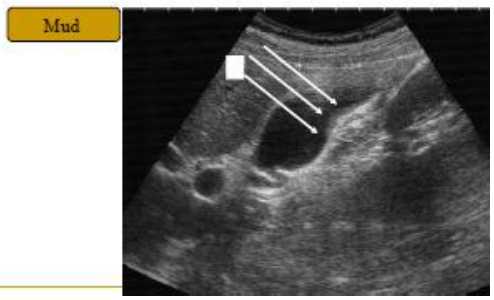
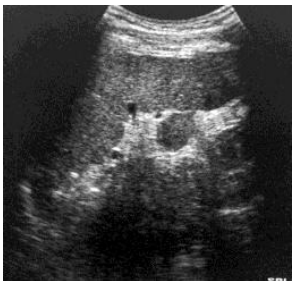


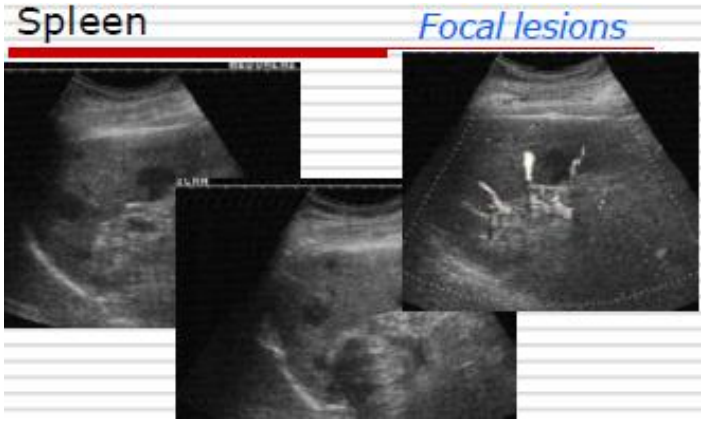
Gall Bladder



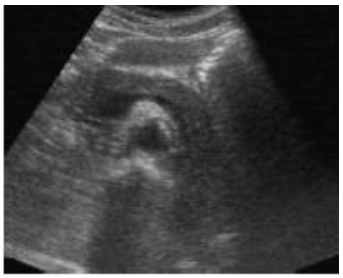
Spleen
Normal

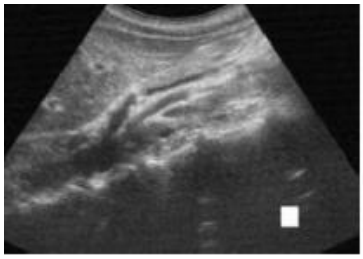

Spleen
Focal lesions

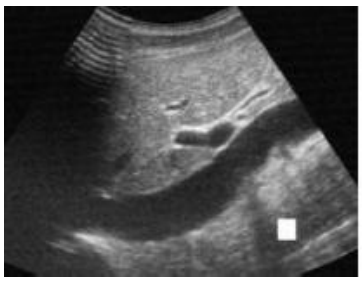


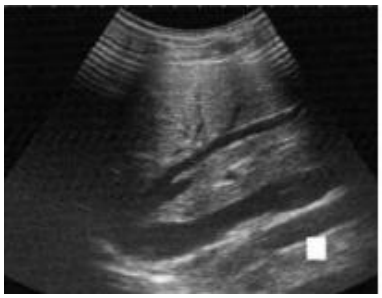



Anatomy
Vascular

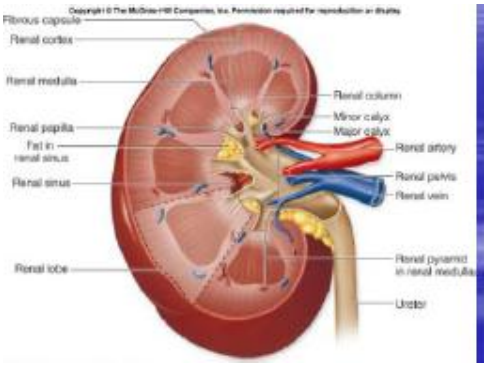


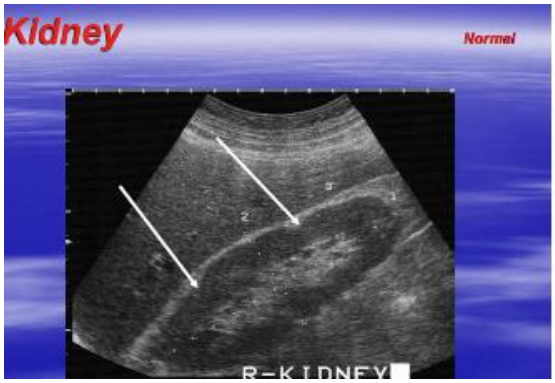


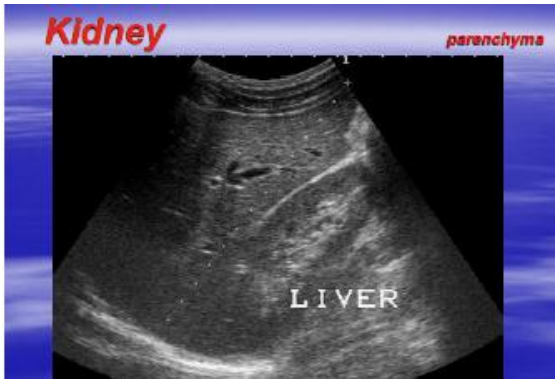




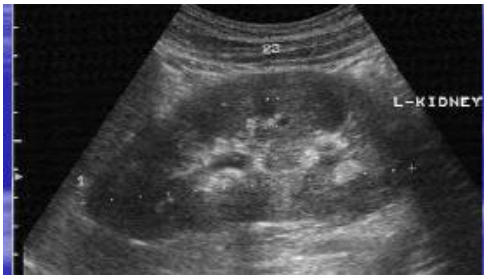
Kidney
Normal

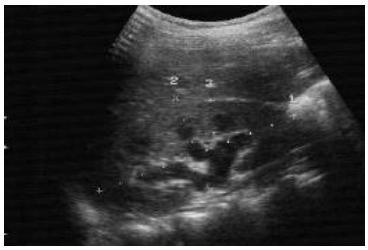






Kidney Back pressure





Kidney Cyst