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A Sound Education

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Center for
Educational Outreach

Baylor College of Medicine

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A Sound Education

Image Reference

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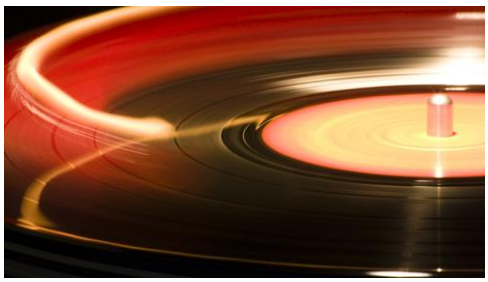
Key Words

amplitude, doppler, energy, frequency, hear, hearing, hertz, Hz, infrasound, sound, sound waves, wavelength, wave crest, wave trough, ultrasound

What Is Sound?

- Sound is an oscillation of pressure, transmitted as waves through solids, liquids, gases and plasma.



- Sound is a form of energy.

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Photo © Ivan Zubar. Used with permission.

What Is Sound?

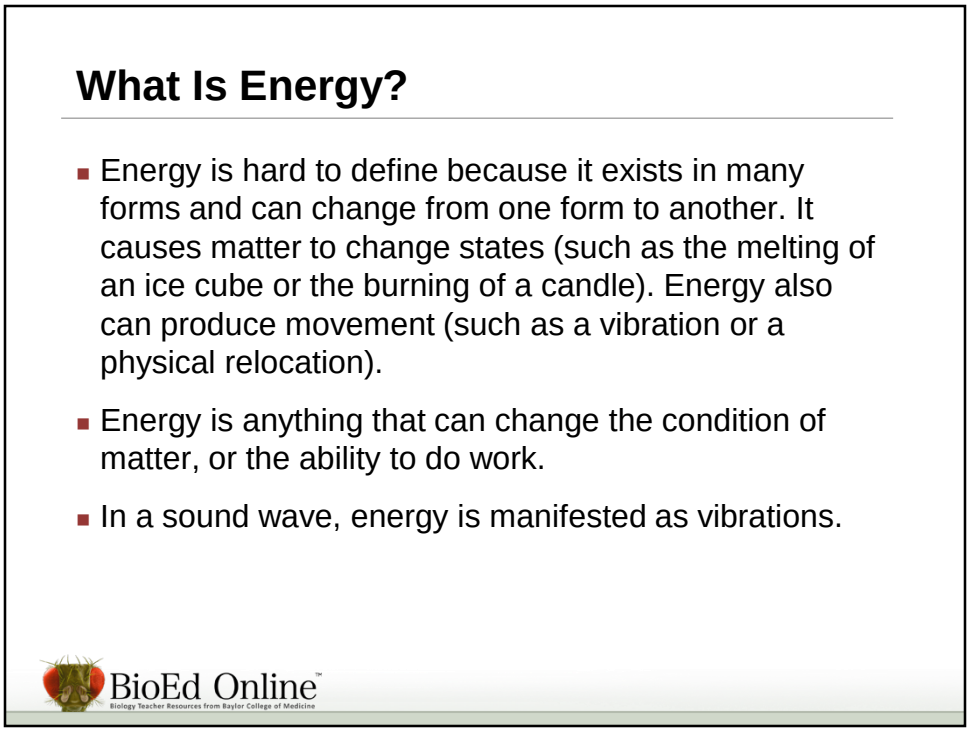
Sound moves through matter in the form of waves. Although we typically think of sound as coming through the air, it also moves through solids, liquids and plasma.

Image Reference

Photo © Ivan Zubar. The Sound of Decadence. Used with permission. http://www.flickr.com/photos/25922018@N07/2776100984

Key Words

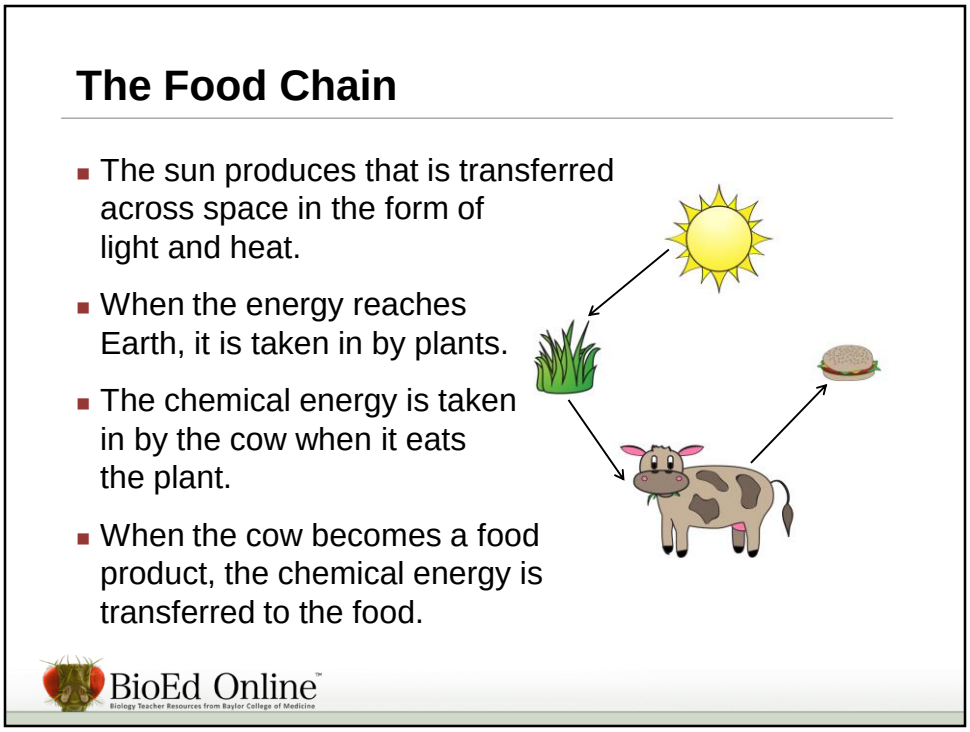
sound, energy, mechanical energy, pressure, sound wave



What Is Energy?

Key Words

sound, energy, matter, mechanical energy, movement, pressure, sound wave, vibration, work



The Food Chain

The sun produces energy through a thermonuclear reaction. The energy is transferred across space in the form of light and heat.

When the energy reaches Earth, it is taken in by plants, in chemical form (carbon dioxide and water), through the process of photosynthesis.

The chemical energy is taken in by the cow when it eats the plant.

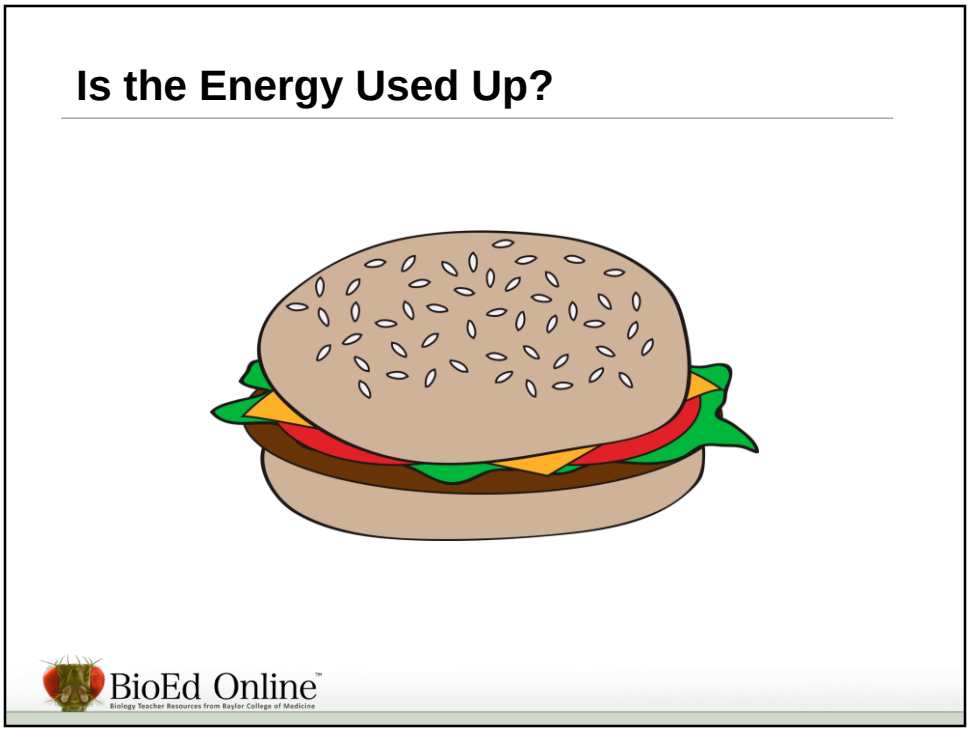
When the cow becomes a food product, the chemical energy is transferred to the food.

Image Reference

Illustration by M.S. Young, BFA, from G.L. Vogt, EdD.

Key Words

sound, energy, animal, chemical energy, cow, electromagnetic radiation, food, food chain, heat, light, matter, mechanical energy, photosynthesis, plant



Is the Energy Used Up?

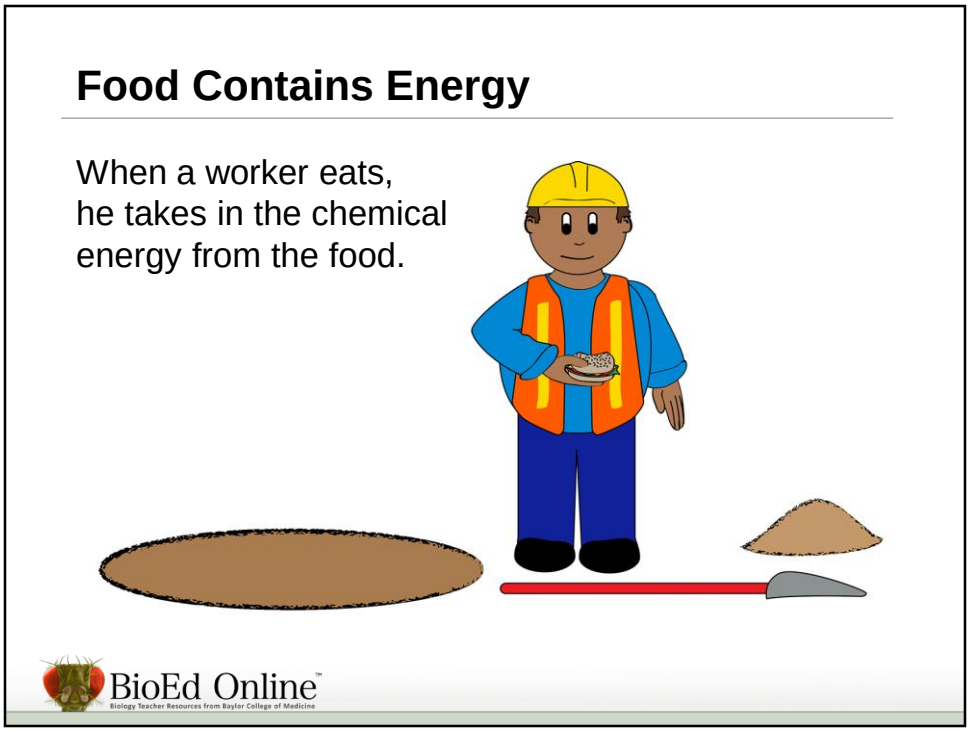
Is the energy used up? [No. When the cow becomes a food product, the chemical energy is transferred to the food.]

Image Reference

Illustration by G.L. Vogt, EdD.

Key Words

sound, energy, animal, chemical energy, electromagnetic radiation, food, food chain, food product, heat, light, matter, mechanical energy



Food Contains Energy

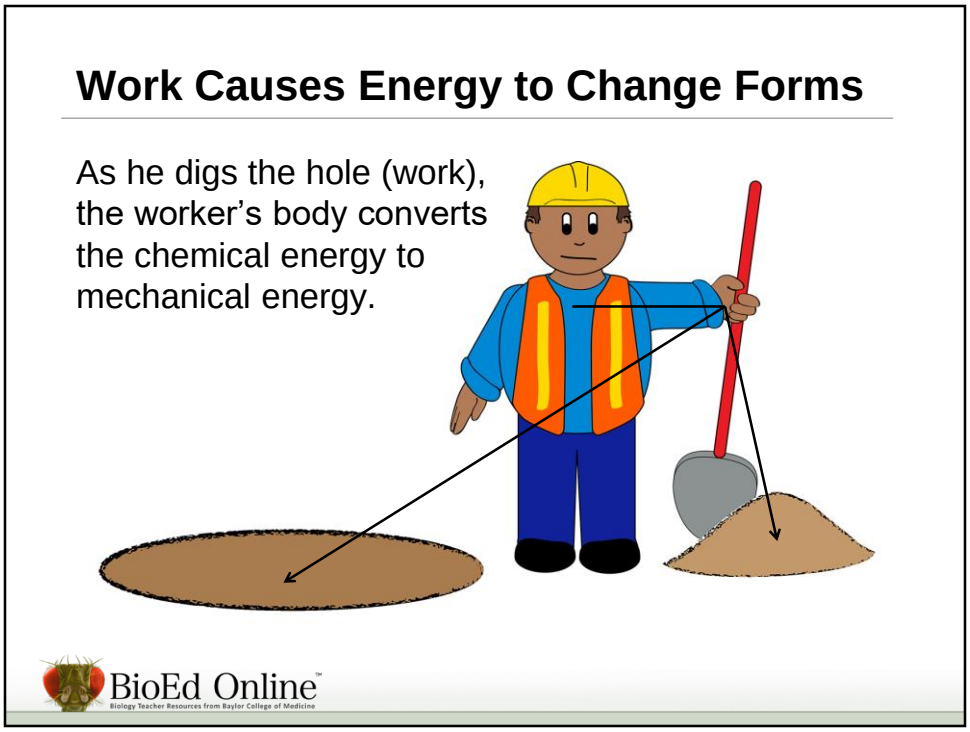
When a worker eats, he takes in the chemical energy from the food.

Image Reference

Illustration by M.S. Young, BFA, from G.L. Vogt, EdD.

Key Words

sound, energy, chemical energy, food, food chain, food product, human, kinetic energy, matter, mechanical energy, work



Work Causes Energy to Change Form

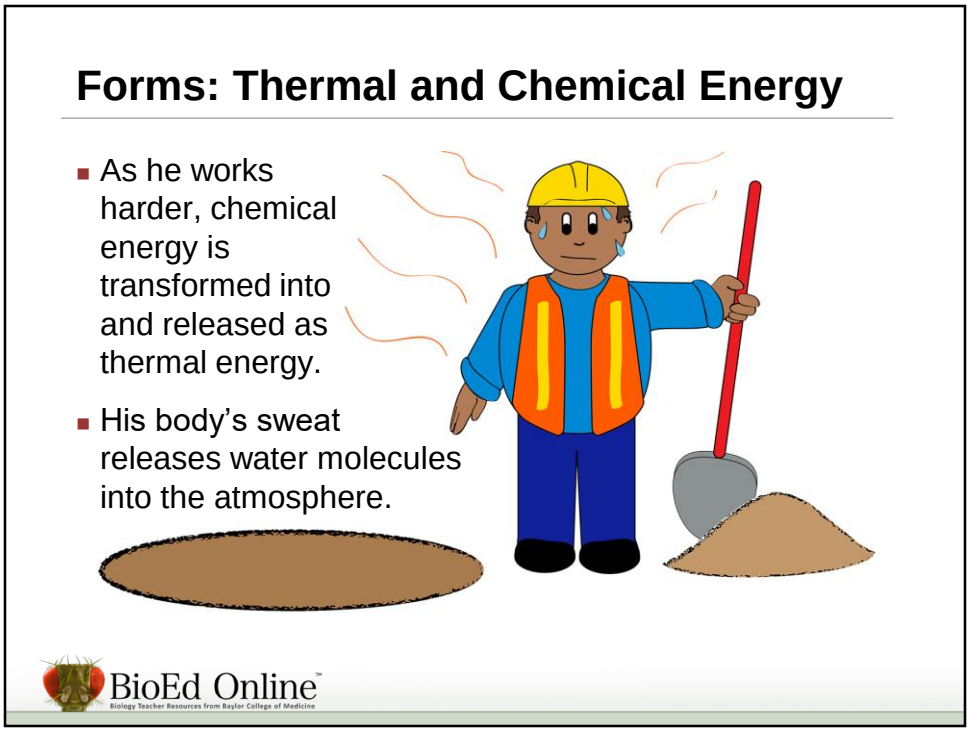
As he digs the hole (work), the worker's body converts the chemical energy to mechanical energy.

Image Reference

Illustration by M.S. Young, BFA, from G.L. Vogt, EdD.

Key Words

sound, energy, chemical energy, food, food chain, food product, kinetic energy, human, matter, mechanical energy, work



From the Worker to Thermal Energy

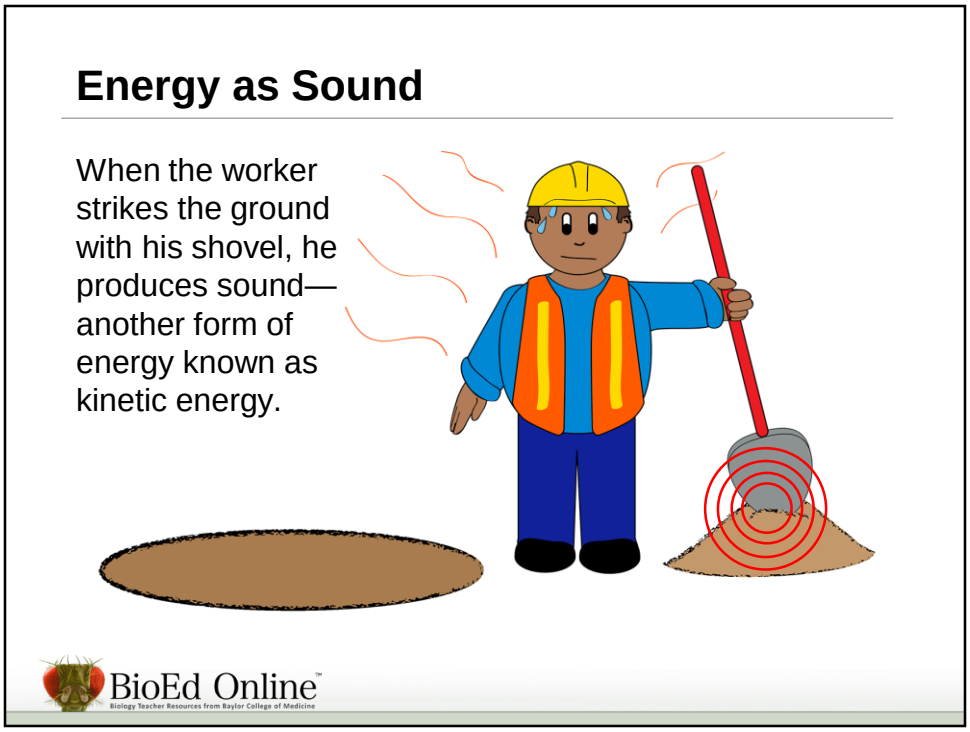
As he works harder, chemical energy is transformed into thermal energy. Sweating releases water molecules into the atmosphere.

Image Reference

Illustration by M.S. Young, BFA, from G.L. Vogt, EdD.

Key Words

sound, energy, chemical energy, food, food chain, food product, heat, human, kinetic energy, matter, mechanical energy, sweating, thermal energy, work



From the Worker's Shovel to Sound!

When the worker strikes the ground with his shovel, he produces sound—another form of energy known as kinetic energy.

Image Reference

Illustration by M.S. Young, BFA, from G.L. Vogt, EdD.

Key Words

sound, energy, atmosphere, chemical energy, food, food chain, heat, human, kinetic energy, matter, mechanical energy, sweating, thermal energy, work

Conservation of Energy

Energy cannot be created or destroyed. It may be transformed from one form into another, but the total amount of energy never changes.

Stellar nurseries, areas where new stars form in space, are made of dense clouds of dust and gas called nebulae. Nebulae are produced by exploding stars.

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Illustration courtesy of NASA.

Conservation of Energy

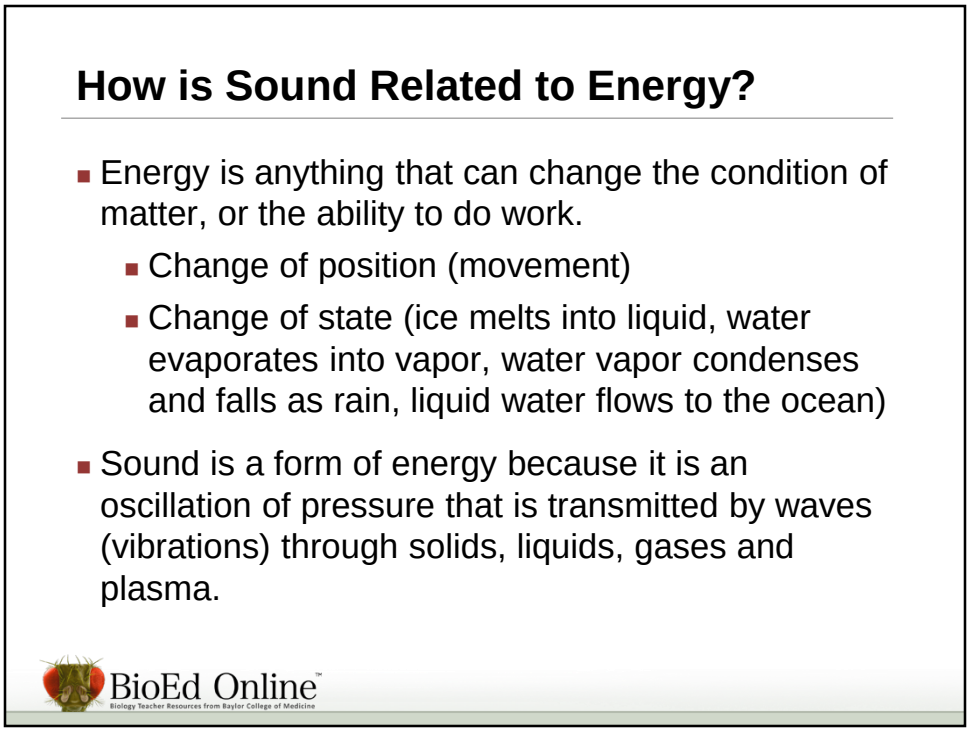
The first law of thermodynamics expresses that energy can be transformed (changed from one form into another), but cannot be created nor destroyed. In other words, in any process in an isolated system, the total energy remains the same. A closed system transfers energy by the processes of heat and mechanical work.

Image Reference

Pillar and Jets HH 901/02. Hubble Space Telescope WFC3/UVIS, courtesy of NASA. http://www.nasa.gov/images/content/447139main_hubble20th-img.jpg

Key Words

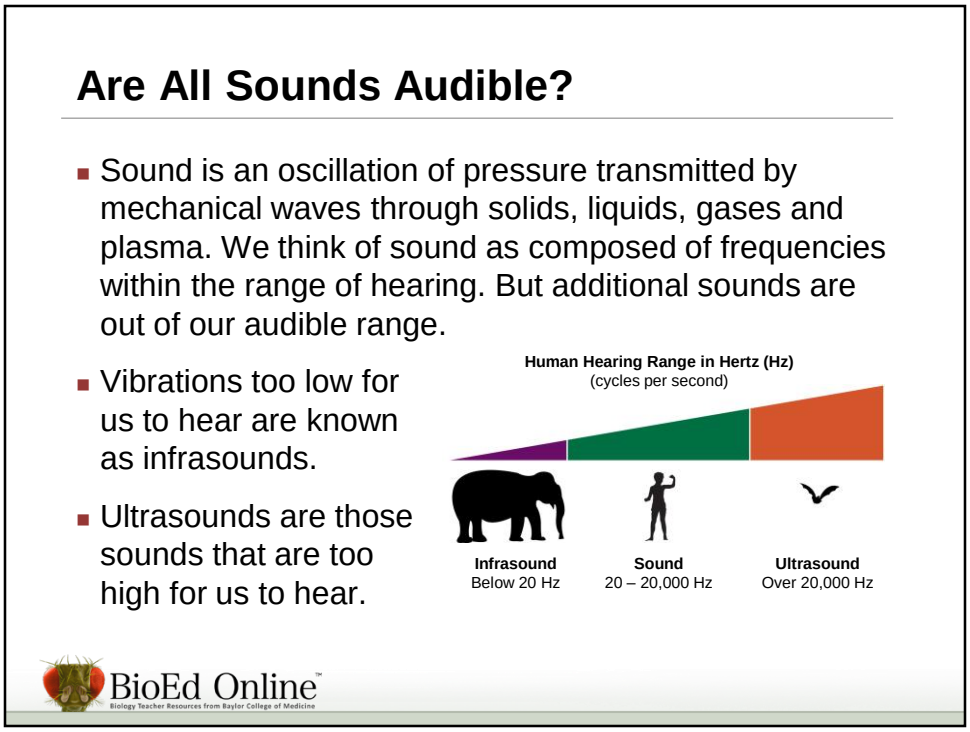
sound, energy, conservation of energy



How is Sound Related to Energy?

Key Words

sound, energy, change of state, matter, oscillation, pressure, vibration, wave, work



Are All Sounds Audible?

While we focus on sounds we can hear, there are other sounds beyond our audible range (range that can be detected by our hearing).

Infrasounds are vibrations too low for us to hear.

Ultrasounds are sounds too high for us to hear.

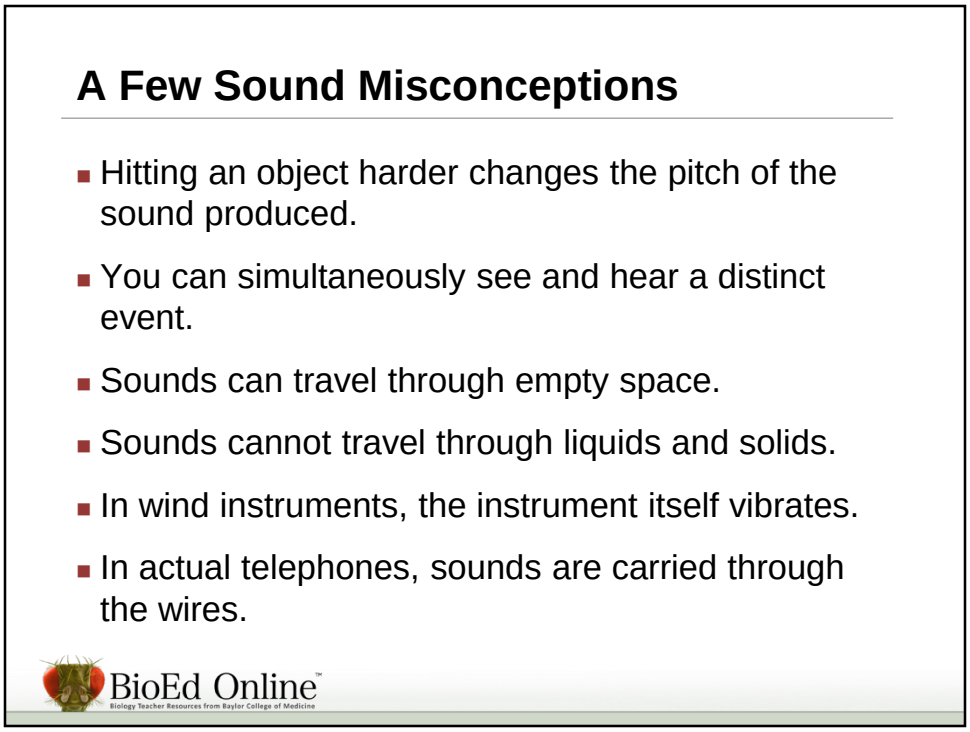
Our ears cannot detect those out-of-range sounds, but technologies allow us to utilize ultrasounds in medicine, geology and many other fields.

Image Reference

Illustration by M.S. Young, BFA from G.L. Vogt, EdD.

Key Words

sound, energy, audible, frequency, hear, hearing, hertz, Hz, infrasound, oscillation, pressure, mechanical wave, sound wave, ultrasound, vibration



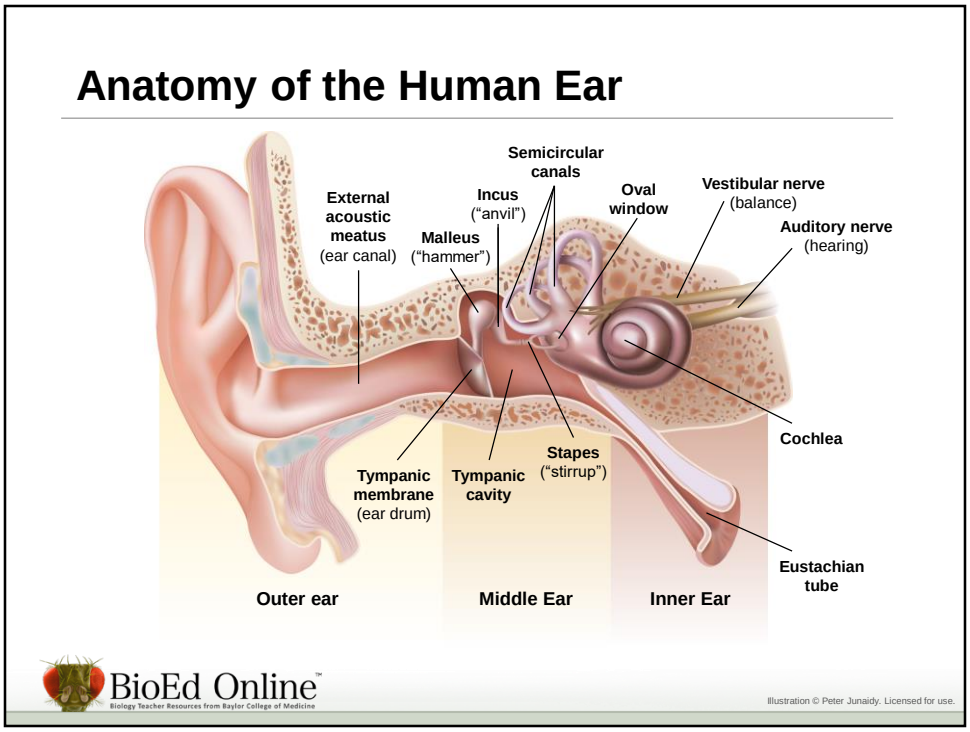
A Few Sound Misconceptions

Reference

Hapkiewicz, A. (1992). Finding a List of Science Misconceptions. *MSTA Newsletter*, 38 (Winter 92), pp.11-14.

Key Words

sound, energy, telephone, vibrate, vibration



Anatomy of the Human Ear

There are three main components of the human ear: the outer ear, the middle ear and the inner ear.

Image Reference

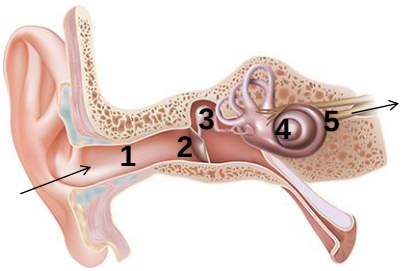
Modified (re-labeled ear parts) illustration 13699578 © Peter Junaidy. Licensed for use.

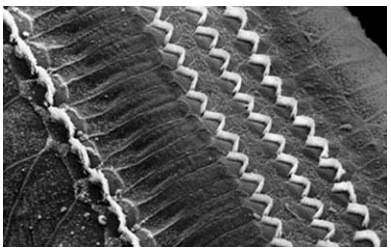
Key Words

sound energy, anatomy, auditory nerve, cochlea, ear, ear canal, ear drum, hear, hearing, incus, inner ear, malleus, middle ear, stapes, outer ear

How Do We Hear Sound?

Sound waves are channeled into the ear via the outer ear structure. They pass through the ear canal, causing the eardrum to vibrate, and then reach the cochlea, where hair cells detect vibrations and transmit electrical signals through an auditory nerve to the brain.





This SEM shows normal hair cells in the cochlea. On the right are three bands of outer hair cells, which amplify sound waves. On the left are inner ear hair cells, which help transform sound waves into electrical signals.

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How Do We Hear Sound?

1-2. Sound waves entering the outer ear pass through the ear canal, causing the ear drum to vibrate.

3. The vibrations of the ear drum focuses waves through the three tiny bones (malleus, incus and stapes) before moving through the oval window into the cochlea.

4. Outer hair cells mechanically amplify low-level sounds that enters the cochlea. Inner hair cells of the cochlea help transform the mechanical sound vibrations into electrical signals.

5. The electrical signals are transmitted via the auditory nerve to the brain. The brain translates the electrical signals into the sound we perceive.

Note: The semicircular canals (oriented along pitch, roll and yaw axes), and vestibular nerve are part of the vestibular system, which contributes to movement and sense of balance. The Eustachian tube helps equalize

pressure between that in the middle ear and atmospheric pressure. It also drains mucus from the inner ear.

References

1.Eustachian tube. Wikipedia CC-BY-3.0. http://en.wikipedia.org/wiki/Eustachian_tube

2.Hair Cell. Wikipedia CC-BY-3.0. http://en.wikipedia.org/wiki/Hair_cell

3.OpenStax College. Hearing. OpenStax CNX CC-BY-3.0. June 20, 2012. http://cnx.org/content/m42297/1.3/

4.Science of Sound and Auditory Injury. Hearing Center of Excellence, U.S. Department of Defense. http://hearing.health.mil/HearingLoss101/ScienceofSoundandAuditoryInjury.aspx

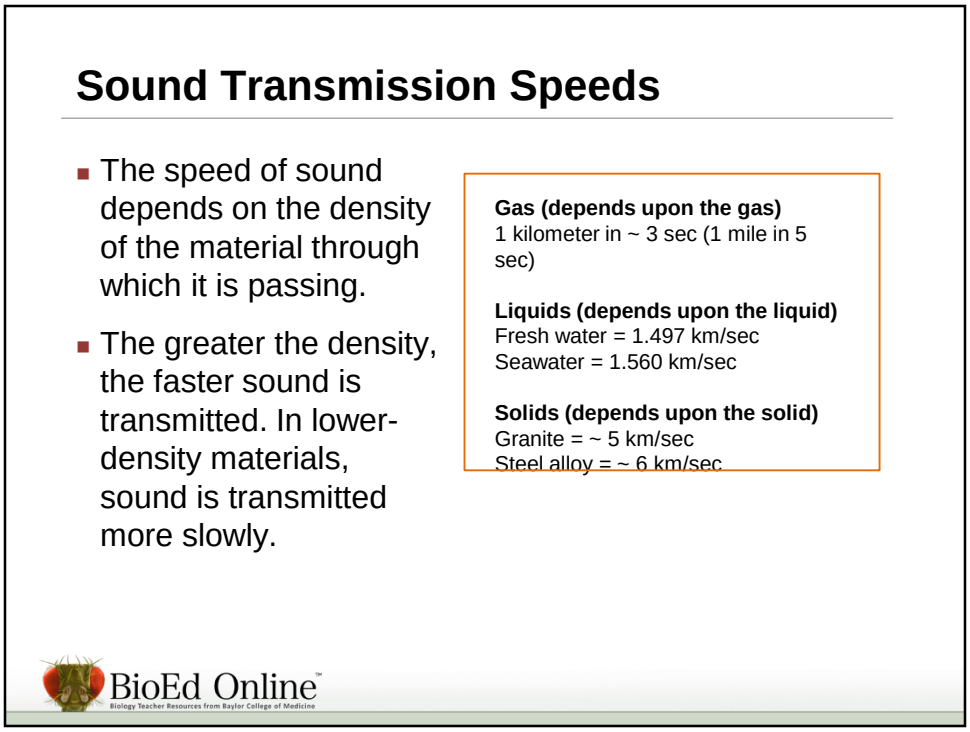
Image Reference

1.Modified (re-labeled ear parts) illustration 13699578 © Peter Junaidy. Licensed for use.

2.SEM courtesy of Andrew Groves, PhD. Integrative Molecular and Biomedical Sciences, Baylor College of Medicine. https://www.bcm.edu/education/programs/imbs/?PMID=9497

Key Words

sound energy, anatomy, auditory nerve, cochlea, ear, ear canal, ear drum, hair cells, hear, hearing, incus, inner ear, malleus, middle ear, stapes, outer ear

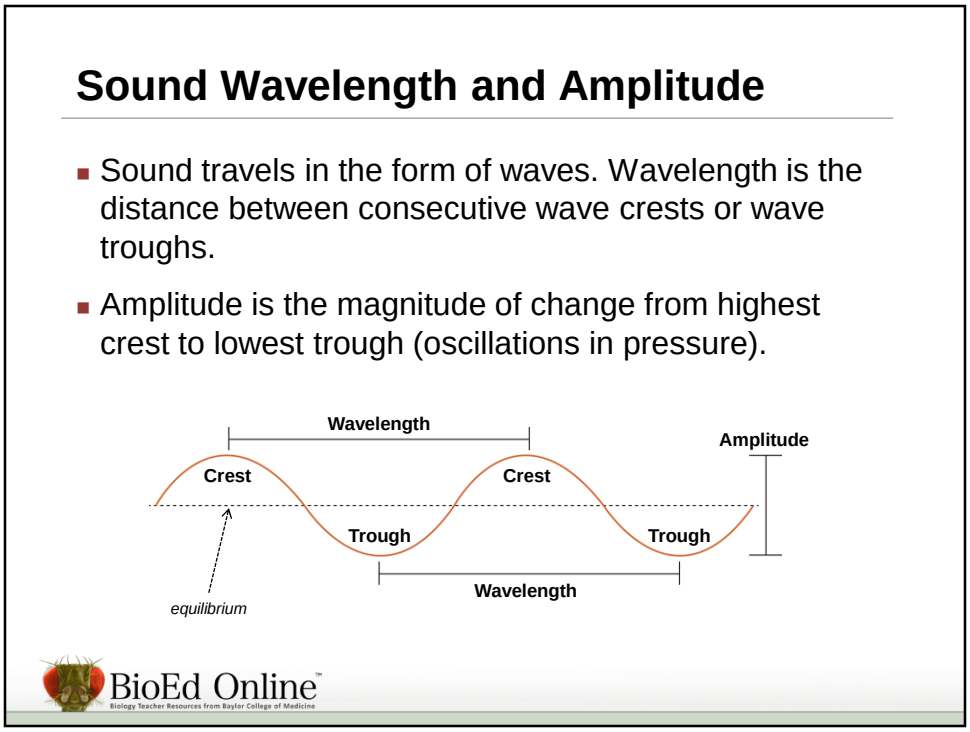


Sound Transmission Speeds

The key to how fast sound waves travel is the density of the media through which the waves move.

Key Words

sound, energy, density, gas, liquid, solid, sound transmission, sound wave, speed of sound,



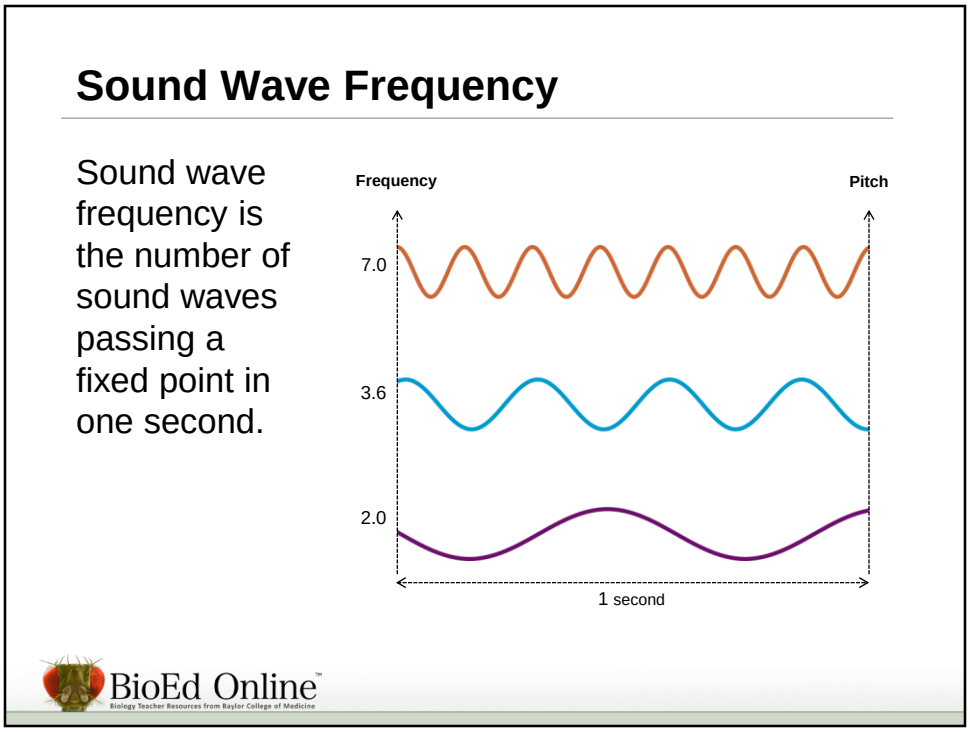
Sound Wavelength and Amplitude

Image Reference

Illustration by G.L. Vogt, EdD.

Key Words

sound, amplitude, oscillation, pressure, wave crest, sound wave, waves, wave trough, wavelength,



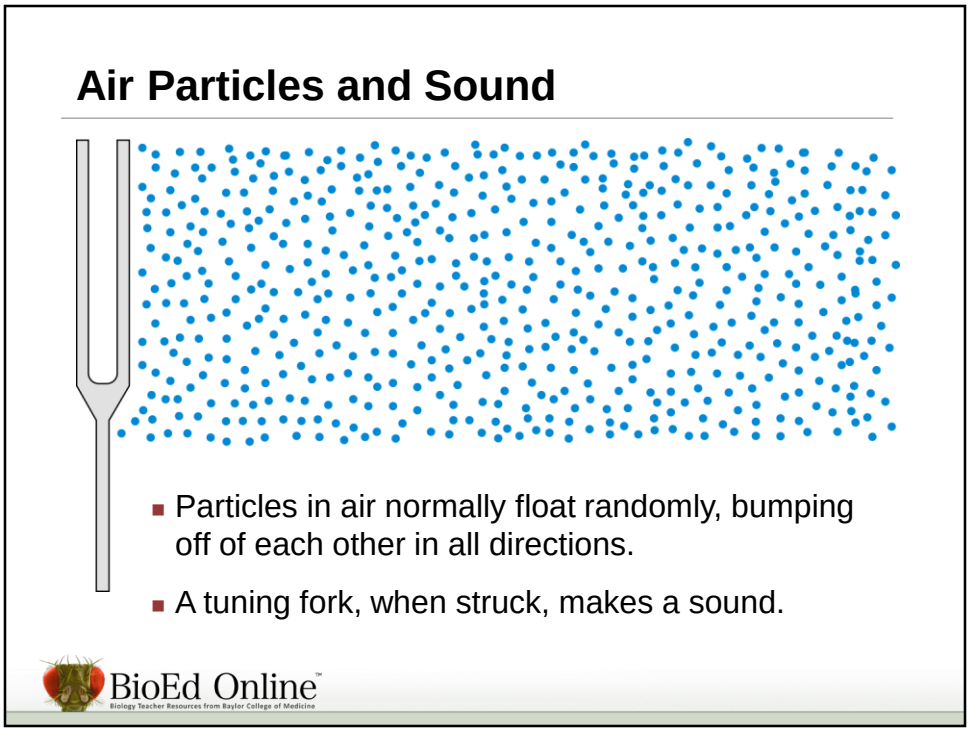
Sound Wave Frequency

Image Reference

Illustration by M.S. Young, BFA, from G.L. Vogt, EdD.

Key Words

sound, frequency, pitch, sound wave, speed of sound, wavelength, waves



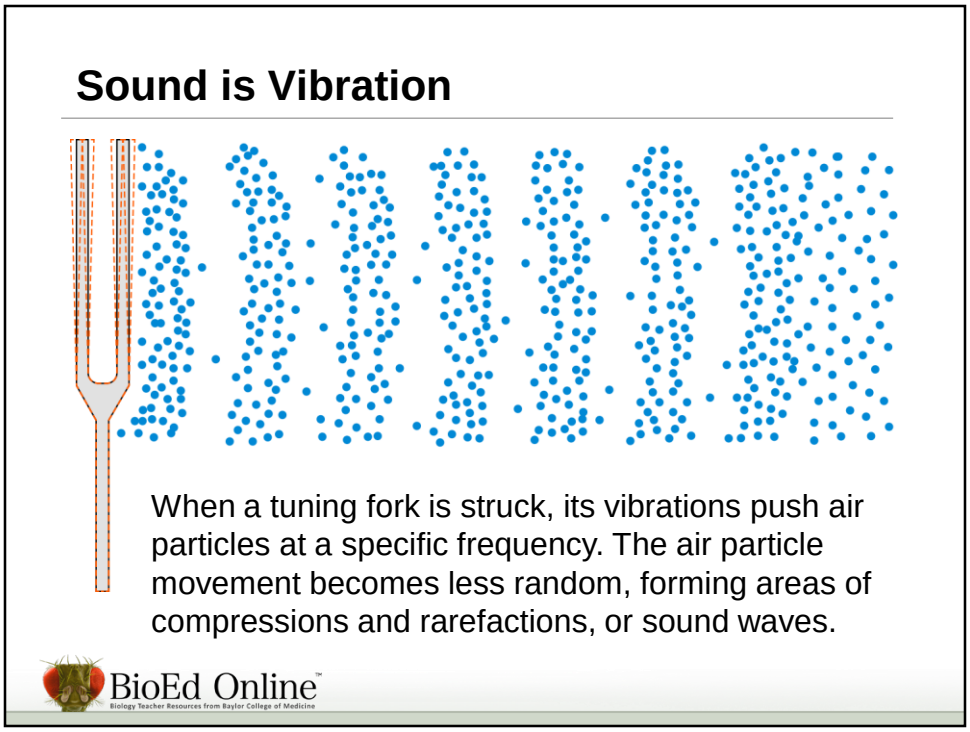
Air Particles and Sound

Image Reference

Illustration by M.S. Young, BFA, from G.L. Vogt, EdD.

Key Words

sound, air particles, tuning fork



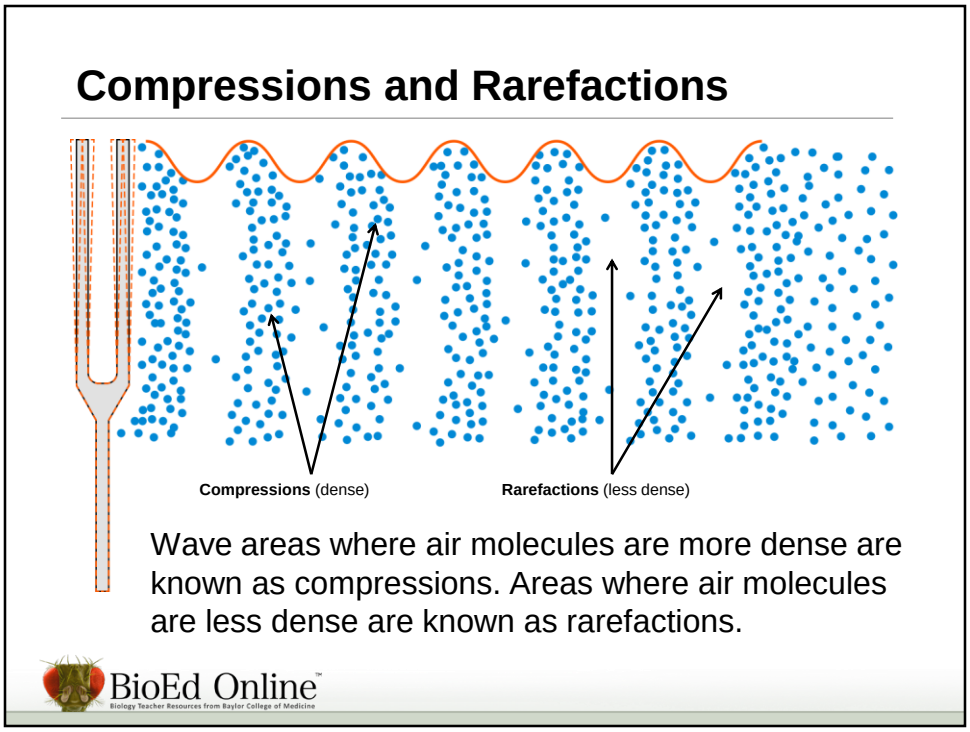
Sound is Vibration

Image Reference

Illustration by M.S. Young, BFA, from G.L. Vogt, EdD.

Key Words

sound, air particles, movement, pressure, sound wave, tuning fork, vibration



Compressions and Rarefactions

The atoms and molecules of gas inside the “tube” become waves that travel the tube’s length. Areas where the air is more dense (crests of the waves) are known as compressions. Areas where air is less dense (troughs of the waves) are known as rarefactions.

Longitudinal sound waves are waves of alternating pressure deviations from the equilibrium pressure, causing compression and rarefaction.

Reference

Sound. Wikipedia CC-BY-3.0.
http://en.wikipedia.org/wiki/Sound_wave#Longitudinal_and_transverse_waves

Image Reference

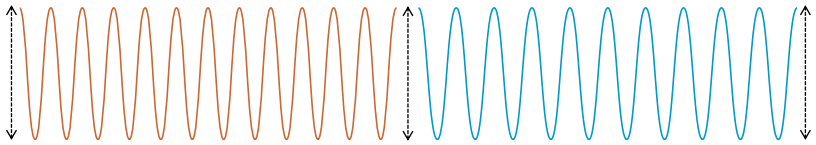
Illustration by M.S. Young, BFA, from G.L. Vogt, EdD.

Key Words

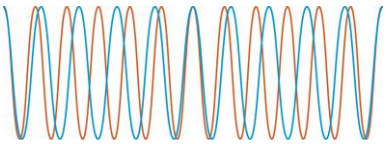
sound, air particles, compressions, movement, rarefactions, pressure, sound wave, vibration

Unsynchronized Wave Action

The two waves shown below have the same amplitude (magnitude of change between highest point (crests) and lowest points (troughs).



When the waves are superimposed, it becomes apparent that they have different frequencies (more “orange” waves).



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Unsynchronized Wave Action

Reference

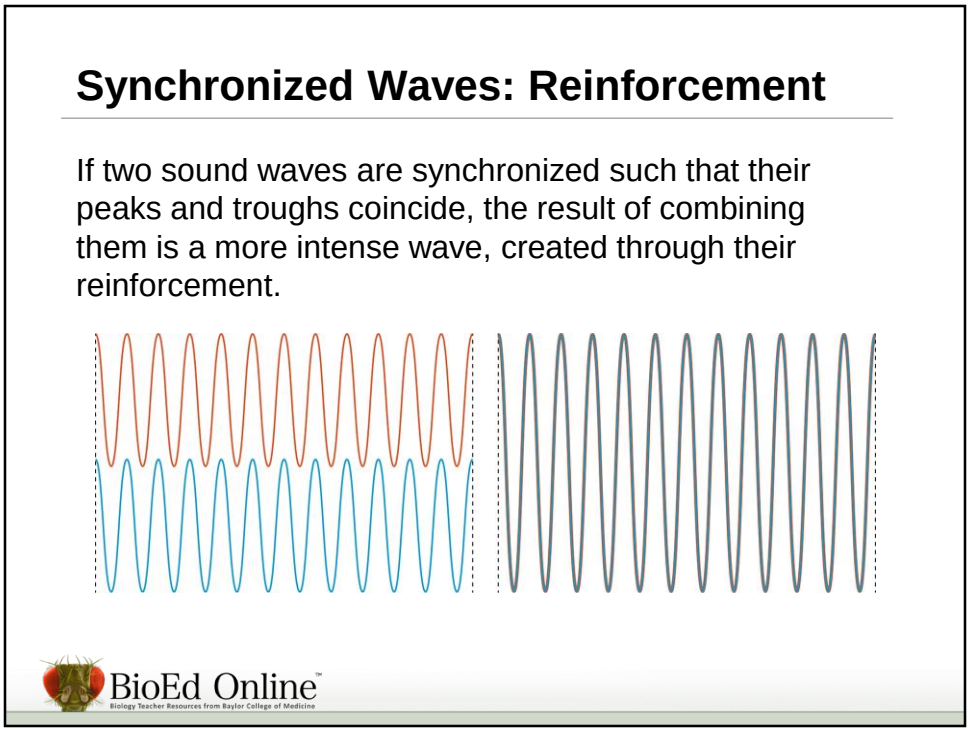
Frequency. Wikipedia CC-BY-3.0. http://en.wikipedia.org/wiki/Frequency

Image Reference

Illustration by G.L. Vogt, EdD.

Key Words

sound, amplitude, sound crest, sound trough, sound wave, unsynchronized wave, wave action



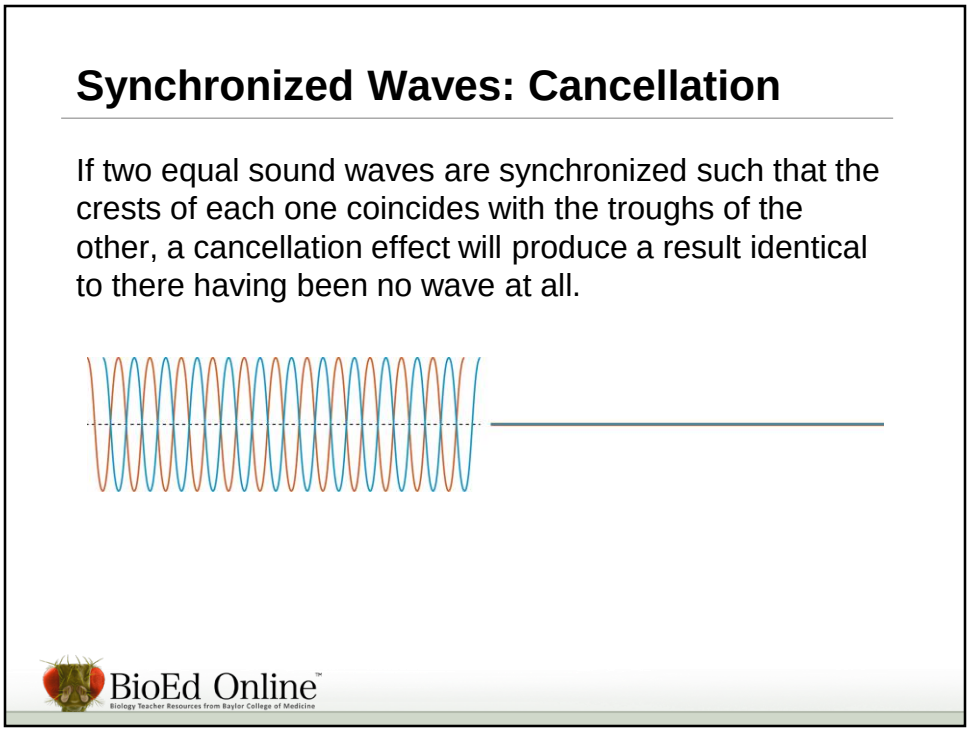
Synchronized Waves: Reinforcement

Image Reference

Illustration by M.S. Young, BFA, from G.L. Vogt, EdD.

Key Words

sound, amplitude, cancellation, reinforcement, sound crest, sound trough, sound wave, synchronized wave, wave action



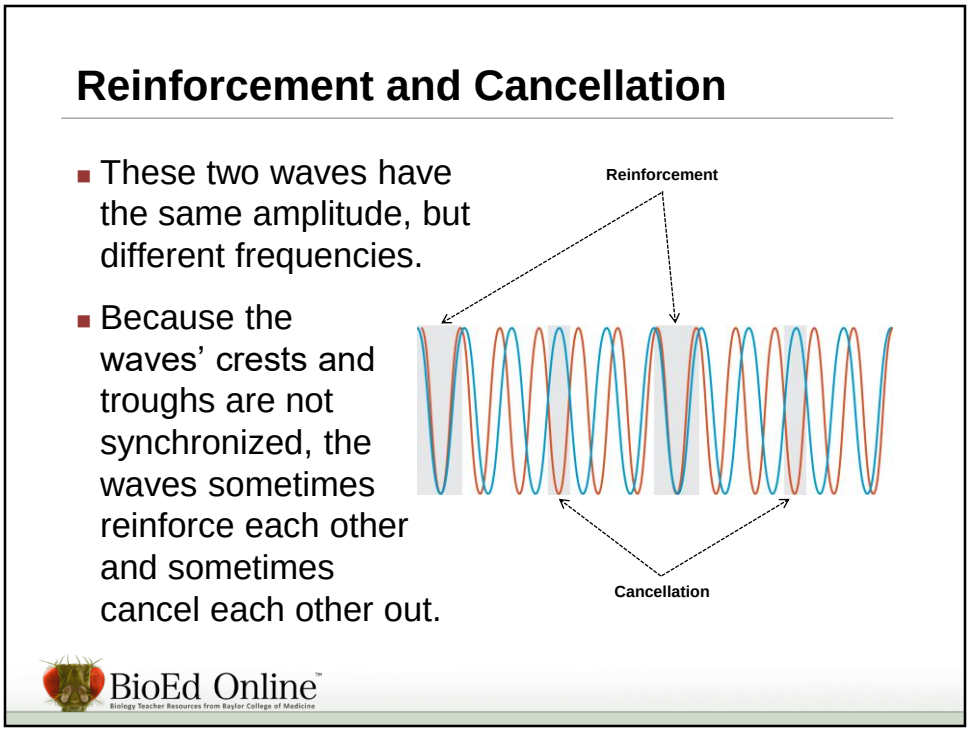
Synchronized Waves: Cancellation

Image Reference

Illustration by G.L. Vogt, EdD.

Key Words

sound, amplitude, cancellation, reinforcement, sound crest, sound trough, sound wave, synchronized wave, wave action



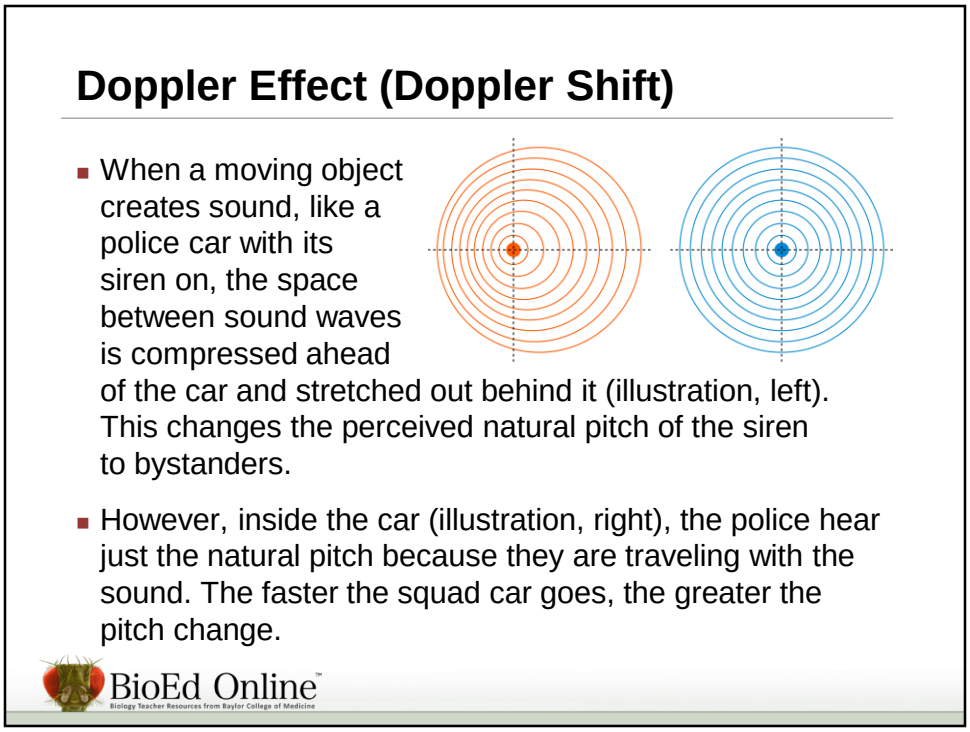
Reinforcement and Cancellation

Image Reference

Illustration by G.L. Vogt, EdD.

Key Words

sound, amplitude, cancellation, reinforcement, sound crest, sound trough, sound wave, unsynchronized wave, wave action



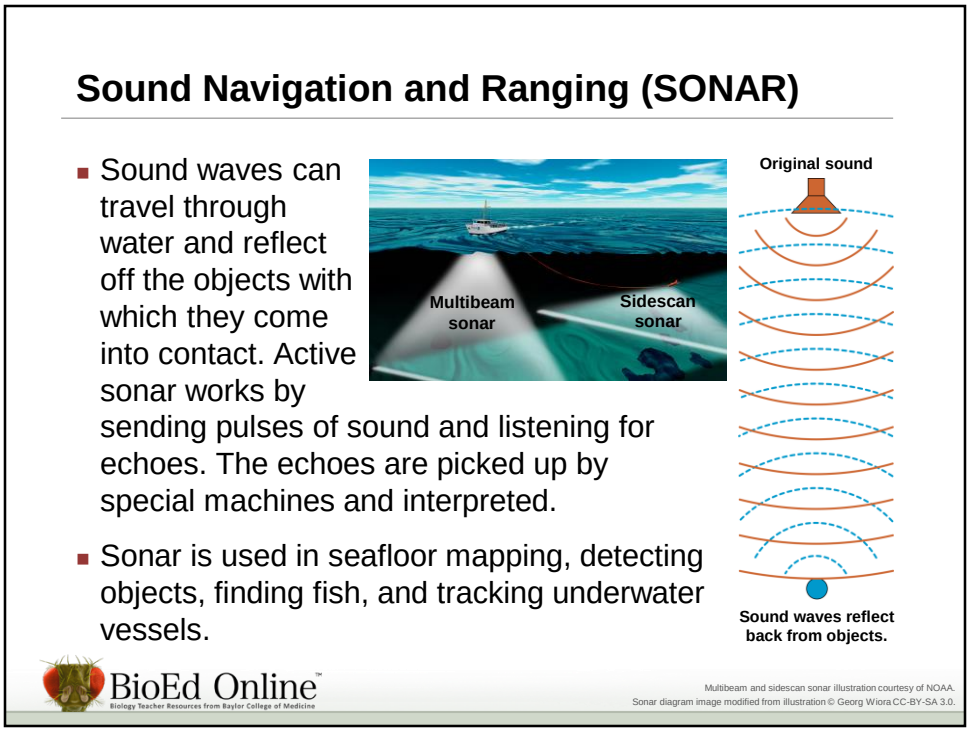
Doppler Effect (Doppler Shift)

Image Reference

Illustration by M.S. Young, BFA.

Key Words

sound, compression, doppler, movement, pitch, sound wave, vibration



Sound Navigation and Ranging (SONAR)

Sound waves can travel through water and reflect off the objects with which they come into contact. Passive sonar is simply listening for sounds made by other objects, such as submarines. Active sonar works by sending pulses of sound and listening for echoes. The echoes are picked up by special machines and interpreted. Sonar is used in seafloor mapping, finding fish, detecting objects, and tracking underwater vessels.

Sonar frequencies vary from infrasonic frequencies (very low) to extremely high frequencies.

Reference

Sonar. Wikipedia CC-BY-3.0. http://en.wikipedia.org/wiki/Sonar

Image References

1.Multibeam and Sidescan sonar illustration courtesy of NOAA.

http://oceanexplorer.noaa.gov/explorations/04fire/background/mapping/media/multi_sonar.html

2. Illustration modified from Sonar_Principle_DE.svg © Georg Wiora CC-BY-SA 3.0. http://commons.wikimedia.org/wiki/Sonar#mediaviewer/File:Sonar_Principle_EN.svg

Key Words

sound, sound wave, seafloor mapping, sonar

Ultrasound

Ultrasound is a sound wave that humans cannot hear. Often used in medicine, ultrasound allows the internal structure of the human body to be seen and imaged. It also is used as a diagnostic tool in veterinary medicine, and in testing of materials to find flaws.

Ultrasound of a normal kidney.

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Ultrasound

Ultrasound is a sound wave that humans cannot hear. Often used in medicine, ultrasound allows the internal structure of the human body to be seen and imaged. It also is used as a diagnostic tool in veterinary medicine and in testing of materials to find flaws.

Reference

Ultrasound. Wikipedia CC-BY-3.0. http://en.wikipedia.org/wiki/Ultrasound

Image Reference

Photo © Nevit Dilmen CC-BY-3.0.
http://commons.wikimedia.org/wiki/File:Kidney_ultrasound_110315132820_1329070.jpg

Key Words

sound, sound wave, ultrasound