SoundWorks

Teacher's exhibition notes

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ScienceWorks and The Observatory Science Centre are part of Science Projects, an educational charity specialising in the communication of science through hands-on exhibits.

WAVE

Sound waves move through air in a similar way to waves moving along a spring
The wave moves, but the spring as a whole does not

DESCRIPTION

Two springs are set into a long frame. The larger spring is enclosed in a clear tube. A knob at one end can be pushed sending a pulse - a compression wave - along the spring. The second spring is narrower and can be touched. By shaking the spring back and forth a pulse or wave sent along the spring can be seen or felt at the other end. In both cases the waves can be seen reflecting from the ends of the springs, and travelling back along them.

CURRICULUM LINKS

Key stage 1
"Pupils should experience the production of echoes resulting from the reflection of sound..."
Key stage 2
"Pupils should learn that sounds are heard because they travel to the ear...Pupils should learn about the reflection of...sound."
Key stage 3
"Pupils should study the way sound is produced and travels as waves through the air".

RELATED EXHIBITS

Tube tangle
Sound waves produced by the voice, channelled through flexible hosing can be heard at the other end.
Vibrating string
The speaker cone moves back and forth compressing small volumes of air, setting up a pressure wave.

WHAT TO DO

Using the <u>large</u> spring, push the knob at the end sharply.

Q: What happens?
(A: A wave or pulse seems to travel along the spring to the other end.)

Q: What happens if you press the knob slowly?
(A: No wave is produced.)

Q: Look carefully at just one coil of the spring as a wave travels past - how does this coil move?
(A: It just moves back and forth once, then becomes still again.)

Q: What happens to the wave when it reaches the other end?
(A: It bounces and travels back along the spring like an echo.)

Shake the <u>smaller</u> spring at the front.

Q: What happens?
(A: Like the big spring a pulse travels along it.)

Q: Which spring has the faster wave?
(A: The smaller spring.)

Hold one end of the spring loosely while a partner shakes the spring back and forth.

Q: What do you feel?
(A: The spring pulses back and forth.)

OTHER THINGS TO DO

Try flicking the end of a long piece of rope. You will see a wave move along it, though it is a different kind of wave ('transverse') to the one in the spring.

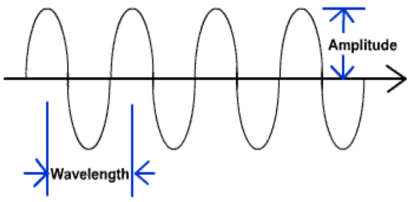
WAVE: FURTHER INFORMATION

Waves
Waves are produced by a back and forth or up and down movement which in turn produces a sort of chain reaction in the medium that the wave is in. This chain reaction effect means that a repeat of the initial movement occurs in the material around it. If it is visible, our eyes see the chain reaction as one continuous travelling effect, known as a wave. Although the material as a whole is not travelling along in one continuous direction, energy is. This means that something in the path of the wave can be pushed or knocked over by it.

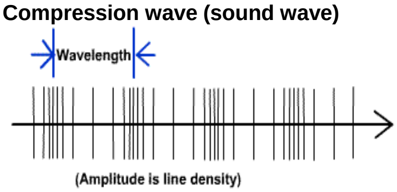
Compression versus transverse waves
There are two types of waves. With one sort, parts of the wave move backwards and forwards in the same direction as that of the wave as a whole. Sound waves, like the waves in the **Wave** exhibit, are this type, known as compression or pressure waves. In the other sort the movement is side to side or up or down at right angles to the direction that the wave is travelling in.

Most other waves, like waves on water, waves moving along a rope, radio waves etc. are of this type (called transverse waves). Waves in the sea look as though they are coming towards us, but in reality the water stays where it is just rising and falling.

Transverse wave (water wave)



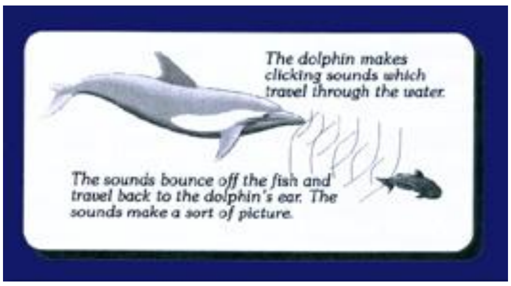
Compression wave (sound wave)



Pulses verses continuous waves
A wave is a repeating process of back and forth (or side to side) movements. This can happen in short or long bursts. A short burst of just one back and forth movement can be called a pulse.

Speed of a wave
Waves travel slowly on the large spring in the exhibit. They travel faster on the smaller spring. Sound waves in air travel much faster, at 330 metres per second. This speed is still far slower then the speed of light waves. Watch someone use a hammer at a distance and you will see the movement long before the sound reaches you.

Echo
When waves strike an object they can be reflected. As with reflection of light, or the bouncing of a ball, the angle of incidence equals the angle of reflection. In sound this produces an echo returning to the source. Some animals like bats and dolphins use this method to detect the location of their prey. It has been developed in ships to do the same thing.



Waves passing through each other
Waves going in different directions may pass through each other, emerging unchanged. When two conversations are going on in a room at the same time, the sound waves are passing through each other all the time. The sounds of the voices are just the same despite this.

EAR CLANGERS

Sound can travel in solid materials as well as in air
Sound travels better in solid materials than in air

DESCRIPTION
Some sets of oven grills are suspended by chains and strings from headphones. The grills have strikers attached to them. The headphones can be put on in the normal way, but the grills should be allowed to hang freely, not held in the hand. It may be necessary to bend forward to do this.

CURRICULUM LINKS
Key stage 1
"Pupils should explore how to make and experience sounds by...striking...using familiar objects...."
Key stage 2
"Pupils should learn that sounds are heard because they travel to the ear and that they can do so via a variety of materials. They should learn that sounds are made when objects vibrate..."
Key stage 3
"Pupils should study the way sound is produced..."

RELATED EXHIBITS
Wave
This exhibit shows a representation of how sound waves move in air and in solid objects.

WHAT TO DO
Put the headphones on. It is essential that the grills hang down freely, suspended by taut chains or strings. Tap the grill.

Q: Describe the sound that you hear.
(A: The sound is a loud, resonant, bell-like sound which continues for some time.)

Q: How does the sound get to your ears?
(A: Through the chains and strings, provided they are taut.)

Q: What do the headphones do?
(A: They act as amplifiers causing the air inside to vibrate, thus vibrating your eardrums.)

Q: Is there any difference in sound using the strings or the chains?
(A: No. The sound travels equally well.

Touch the grill gently with your fingers after it has been tapped.

Q: What can you feel?
(A: Vibrations.)

Q: What happens if you hold the grill firmly?
(A: The sound stops.)

Strike the grill with the head phones off.

Q: Describe the sound compared with the headphones on.
(A: It is much quieter and stops quickly.)

Q: Do the vibrations of the grill feel different?
(A: The same.)

Q: How does the sound get to your ears without the headphones?
(A: Through the air.)

EAR CLANGERS: FURTHER INFORMATION

Sound can travel in solid objects
In the same way that sound can travel through air, it can also travel inside other materials such as metal. Sound travels better in some materials than in others, and it travels in metals particularly well. This means it travels faster and further.

When the oven grill is struck, sound waves are started within the metal bars. These sound waves are vibrations which travel up and down the bars and the chains and strings. They can be felt by touching the grill bars gently.

Sound waves do not travel easily from one material into another. With the headphones on the sound travels direct from the metal grill, up the chains and strings and a loud sound is heard. However, with the headphones off, the sound must pass from the metal bars into the air and through the air to the ears, resulting in a much quieter sound.

Sound travels faster through some materials than air
Sound waves travel particularly well in many metals, ceramics and liquids. In these materials sound waves travel faster than in air and carry further.

Speed of sound in different materials

Air	330 metres per second
Water	1400 metres per second
Brick	3600 metres per second
Iron	5100 metres per second
Aluminium	5100 metres per second
Glass	6000 metres per second

Sound causes the molecules of a substance to vibrate, which is passed along to neighbouring molecules more easily if they are tightly packed. As a general rule sound travels faster through denser materials.

Sound does not travel through a vacuum
If all the air in a bell-jar containing a ringing bell is sucked out, you will not hear the sound. Because there are no molecules in a vacuum there is nothing to vibrate. In space, no one can hear you scream!

Taut chains or springs
If the chains or strings are to vibrate then they need to be taut in order that the elasticity keeps the vibration going. It is essential that the grille hangs freely. A slack chain or string will not vibrate if displaced.

String telephone
Make a string telephone. Put a small hole in the bottom of two tins or strong plastic cups. Thread a long piece of string through the holes and knot them inside. With a partner far enough away to keep the string taut, you can have a conversation alternatively speaking and listening to the cups. Provided the string is kept taut, sound vibrations will travel along it in the same way as along wire or solid rod.

TEA CHEST BASS

Tension in a string affects the pitch of sound it makes A large surface vibrating makes a louder sound than a small one

DESCRIPTION

A large hollow box has a string attached to the top. The string is also attached to a socket which can be placed over the end of a wooden stick. The stick is tilted over to tighten the string which can then be plucked. Sound emerges mainly from the open side of the box.

CURRICULUM LINKS

Key stage 1
"Pupils should explore how to make and experience sounds by plucking using familiar objects and simple musical instruments..."
Key stage 2
"...learn that sounds are made when objects vibrate, and investigate how sounds are changed in pitch...by changing characteristics of the vibrating object, for example, by changing...tension".
Key stage 3
"Pupils should study the way sound is produced and travels through the air. They should have opportunities to investigate...relationships between loudness, amplitude, pitch and frequency".

RELATED EXHIBITS

Resonance
Wooden drums and glockenspiels are used to explore what effect limiting the amount of vibration has on the volume of sound.
Ear clangers
The vibrations of the grill are amplified by the hollow headphones.
Vibrating string
A string attached to the cone of a speaker vibrates according to the note played.

WHAT TO DO

Using the stick, tighten the string. Pluck it.

Q: What happens when you pluck the string?
(A: The string vibrates - moves from side to side very quickly. A musical note is heard.)

Q: Where is the sound coming from?
(A: The open side of the wooden box.)

Putting a foot inside the box holds it down, allowing you to pull the string tighter.

Q: What differences does tightening the string make?
(A: The string moves from side to side rapidly. The pitch of the note is higher.)

Q: What differences does loosening the string make?
(A: The string moves from side to side slowly. The pitch of the note is lower.)

Q: What happens if you tighten or loosen the string while a note is sounding?
(A: The pitch of the note changes also.)

Pluck a note and watch the string for one minute. What happens?

Q: Can you still see the string moving after the note has faded away and can no longer be heard?
(A: Yes.)

MORE THINGS TO DO

You can also alter the length by holding the string against the pole with your fingers and moving your hand up and down the pole while you pluck it with the other hand.

TEA CHEST BASS: FURTHER INFORMATION

The loudness of the sound

When an object vibrates, its movement causes the air around it to move. The motion produced in the air itself is similar to the motion of the object, i.e. a back and forth movement. This movement is transmitted outwards through the air so that air at some considerable distance may also be moving back and forth in the same way as the original object. If it reaches our ears, this movement is detected as sound.

The string vibrates when it is plucked. Because the string is thin, this movement does not push against much of the air around it, so the string itself does not start strong vibrations in the air.

The movement of the string moves the top of the wooden sound box which acts as an amplifier. Because the top of the box is large its movements push more air, causing air to vibrate. Vibrations of the air inside the box are reflected out of the opening, and this is where the sound is loudest. The same applies to any stringed instrument like a violin or acoustic guitar. In electric guitars the amplification is done electronically.

Varying the pitch

When a string is plucked it produces one particular note. The pitch of the note depends on four things:

1. The tension or tightness of the string.
2. The length of the string.
3. The weight of the string.
4. The elasticity of the string.

In this exhibit you can only vary the first easily and with more difficulty the second. Stringed musical instruments can make use of the other ways to enable the player to play different notes. For example, harps and pianos have different length strings. Guitars have heavier strings for the low notes, thinner ones for the high notes and the strings are set at different tensions. The pitch can also be altered by fretting which shortens the length of the string.

Double bass

A conventional double bass works on similar principles to the tea chest bass: a sound box, an upright and strings that can be plucked. In this instrument the notes are changed by shortening the vibrating length of the strings by pressing them against the upright.

Skiffle groups

Back in the 1950s bands made music with the simplest and cheapest instruments they could obtain or make. They included the washboard and thimble, the whistling jug, the musical saw, the cigar box fiddle and the comb and paper. The core instrument was the tea chest bass. You can make quite a racket with that lot, which is why they tended to include a guitar or a banjo to create more mellifluous sounds.

SOUND OR MUSIC

Vibrations - rapid back and forth movements - are necessary to produce sound
To create sound an object must be able to move freely

DESCRIPTION

This exhibit has two parts. The first consists of two wooden drums. These drums apparently have tongues cut into the top surface. One drum is normal, i.e. hollow; the other is filled with hard material and is effectively solid.

The second part consists of two glockenspiels. One of them has the bars screwed down on to foam rubber; this affects the sound it produces.

CURRICULUM LINKS

Key stage 1
"Pupils should explore how to make and experience sounds by...striking...using simple musical instruments...."
Key stage 2
"Pupils should learn that sounds are made when objects vibrate, and investigate how sounds are changed in pitch, loudness and timbre, by changing the characteristics of the vibrating object".
Key stage 3
"Pupils should study the way sound is produced...Pupils should investigate the effect on sound of the shape...used..."

RELATED EXHIBITS

Bucket radio

This exhibit deals with sound being produced by vibrations. It allows the vibrations making the sounds of a radio to be felt.

WHAT TO DO

Tap each of the wooden drums and examine them carefully.

Q: Describe the differences in sound produced by each drum.
(A: One drum makes clear notes (i.e. a musical sound of a particular pitch), while the other drum makes no proper notes at all - just a dull thud).)

Q: Why is this?
(A: One drum is hollow while the other is effectively solid. The tongues of the hollow one can vibrate to make a sound.)

Tap each of the glockenspiels, paying careful attention to the differences between them.

Q: Describe the difference in the sound made by each glockenspiel.
(A: The sound made by the one with the bars on foam rubber is dull and dies away quickly. The other is clear and ringing.)

MORE THINGS TO DO

Put your finger lightly on the ends of the tongues, while you tap the drums.

Q: What do you feel?
(A: Tingling vibrations on the hollow drum but not on the solid one.)

Similarly, if you touch gently the edge of a glockenspiel bar which makes a ringing sound when you strike it, you will feel a slight tingling vibration

RESONANCE: FURTHER INFORMATION

The glockenspiel

A glockenspiel (German: ‘playing bells’ or more strictly, ‘clock sound’) has metal bars but is otherwise similar to a xylophone, which is made out of wood (Greek: xylon = wood; phono = sound). When a bar is tapped, the bar vibrates - the movement is actually greatest at the ends of the bar. The length of the bar affects the speed of vibration which determines the pitch of the note produced. This is why an individual bar always makes the same note.

When the glockenspiel with the bars screwed tight is tapped the bar starts off vibrating in the normal way - if you could hear the beginning part of each note the two glockenspiels would sound the same. Very soon however the foam rubber pressing on the bar dampens down the vibration, and therefore the sound.

Wooden drums

To make sound there must be something which can vibrate or move. The completely hollow drum makes notes because the ‘tongues’ of wood are flexible and can move or ‘flap’ up and down, thus vibrating air. The movement is too rapid to see but can easily be felt.

The other drum cannot make distinct notes because the ‘tongues’ of wood cannot vibrate. This is because they are joined to the main block of wood which is too heavy and inflexible to vibrate.

Musical instruments

The effect of a hollow space is to make the sound louder and clearer. This happens because the vibration spreads to the sides and base of the drum and these vibrations also make sound. The precise way this happens is complex. The materials used and the shape of the sound box can affect the way in which it vibrates, which in turn affects the quality of the sound produced.

MODEL EARS

The ear has many parts which we cannot see
The ear is a highly sensitive organ

DESCRIPTION

A pair of model ears is provided, showing the structure of the internal as well as external part of the ear. There are two removable parts in each.

CURRICULUM LINKS

Key stage 2
"Pupils should learn that sounds are heard because they travel to the ear..."
Key stage 3
"Pupils should study...how the ear works"

RELATED EXHIBITS

Tube tangle
One tube is can be connected via a diaphragm which transmits sound like the one in the ear.
Wave
This exhibit demonstrates how sound waves travel, and how they can have an effect on what they strike.

WHAT TO DO

Look at the ears.

Q: Are they left or right ears?
(A: They are both left ears.)

Try to put the small parts in the correct places on the model.

Q: Can you identify the ear drum?
(A: See diagram.)

Q: Which way do you think the sound goes?
(A: From the outer, visible ear down the ear canal, to the ear drum.)

Q: What do the ear drums in your ear do when sound gets to them?
(A: They are like the skin of a drum and they vibrate in the same way.)

MORE THINGS TO DO

Looking carefully at the model, try to trace the route of the sound or vibration from the ear drum, through the middle ear, and into the inner ear.

Q: Can you see the small bones - the hammer, anvil and stirrup. Why do you think they were named like this?
(A: See diagram - because the hammer bone moves against the anvil bone, and the stirrup bone looks like a riding stirrup. They are vibrated by the ear drum and they vibrate the inner ear in its turn.)

Look at the inner ear. Can you find the snail-like cochlea which is the actual sound sense organ? Look for the nerve connection from the ear to the brain, and for the parts of the inner ear which help control our sense of balance. They are called the semi-circular canals, because of their shape.

MODEL EARS: FURTHER INFORMATION

Hearing sounds

Sound waves, which are a chain reaction of back and forth movements of air, may enter our ears. These movements cause vibration of the ear drum. It is a thin oval membrane, supported by a ring of muscle which can tighten or loosen it.

Behind the ear drum is the middle ear. In it are three small bones. They are very precisely arranged, to transmit and amplify the movements through them passing the vibrations to a second membrane.

On the other side of this membrane is the inner ear, the cochlea which is a snail-like spiral, with highly sensitive hairs inside and filled with a fluid. The vibrations pass into the cochlea and the hairs respond to the vibrations, creating nerve signals which travel via the auditory nerve to the brain.

Interpreting sounds

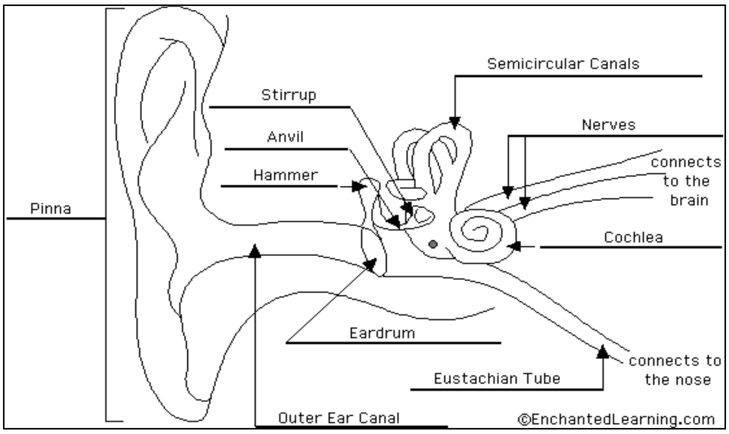
Each different sound produces vibrations of a slightly different pattern. Our ears and brains detect these accurately to identify the source and many other characteristics of the particular sound. Two ears help us identify the direction a sound is coming from.

Balance

Part of the fluid-filled inner ear also helps us balance. Three loops, the semi-circular canals, each at a different angle to each other, extend out from the cochlea. The movement of the fluid inside these loops is detected as our head moves and the information is sent to the brain via the auditory nerve. Problems that affect the inner ear may also affect an individual's sense of balance.

External ear

The shape of the external ear or pinna with its curves and convolutions is as peculiar to an individual as a fingerprint. Even identical twins do not have absolutely identical ears.



BUCKET RADIO

Sounds are made when objects vibrate
A large vibrating surface makes a louder sound than a small one

DESCRIPTION

A radio has its loud speaker removed and the wires connected to a unit with a short peg sticking up through a clear sheet. Electrical signals from the radio, carrying a representation of the sound, cause the peg to vibrate up and down.

Touching the peg lets you feel the changing vibrations. Placing objects onto it, such as the bowl, can make the sound audible.

CURRICULUM LINKS

Key stage 1

"Pupils should have the opportunity to experience the range of sounds in their immediate environment and to find out about their causes and uses."

Key stage 2

"Pupils should learn that sounds are made when objects vibrate."

Key stage 3

"Pupils should study the way sound is produced. They should have opportunities to investigate ...relationships between loudness, amplitude, pitch and frequency."

RELATED EXHIBITS

Resonance

Wooden drums can be used to feel the vibrations of these instruments when struck.

WHAT TO DO

Put your finger gently onto the 'peg' sticking up through the clear plastic.

Q: Describe what you feel.
(A: Vibration/movement/buzzing, etc.)

Q: Do the movements you can feel stay the same all the time?
(A: No, they seem to change, sometimes strong, sometimes weak.)

Q: Can you hear anything?
(A: By putting your ear close to the peg the faint sound of the radio can be heard.)

Place the plastic bowl gently on top of the peg.

Q: Now what can you hear?
(A: The radio station can be heard quite clearly. The bowl is acting as a loudspeaker)

MORE THINGS TO DO

Touch the bowl gently.

Q: Can you feel vibrations?
(A: Yes, if you touch gently enough.)

Hold the bowl down firmly while it is still touching the peg.

Q: What differences does this make to the sound of the radio and why?
(A: The sound gets quieter, because the vibrating movements of the bowl have been prevented.)

Place the metal bowl onto the peg.

Q: How does the sound compare with the plastic bowl?
(A: It is more rattly and harder to hear in accordance with the material.)

BUCKET RADIO: FURTHER INFORMATION

Vibrations
The radio makes electrical signals which, when fed into certain devices like loud speakers, cause vibrations. The pattern of the vibrations corresponds faithfully to the pattern of vibrations which were in the air when the recording of the music or speech was made.

The vibrations are strong when the sound is loud, weak when it is quiet and stopped when it is silent (for example in pauses between sentences). Although we can feel the general back and forth movement with our fingers (except for very high pitched sounds) we cannot feel the precise way in which the movement is happening and therefore cannot distinguish between, say, vibrations of different musical instruments by touch.

Vibrations into the air
When an object vibrates, its movement causes the air around it to move. A small vibrating object, even if its vibrations are strong, will not cause much air to move. If, however, the object is larger, it will cause more air to be moved.

Vibrations in the air are necessary for us to be able to hear sounds in the normal way. So, large vibrating objects which can make a lot of air move tend to make more noise than small ones.

In addition, a heavy object is more difficult to vibrate than a light one. The best kinds of object for allowing vibrations to pass strongly into the air are light in weight and have a large area of contact with the air. Loud speaker cones which are made out of paper or light plastic are good examples of this.

The plastic bowl in this exhibit works quite well as a loud speaker while the metal one is less effective.

HEARING TEST

Sound can vary in pitch (frequency)
Our hearing can alter with age

DESCRIPTION
The exhibit is a sound source which can be tuned to different frequencies using the knob. A read-out displays the frequency in kilo Hertz. Pupils can test their hearing to see how high a frequency they can hear.

CURRICULUM LINKS
Key stage 1
“Pupils should have the opportunity to experience the range of sounds in their immediate environment and to find out about their causes and uses.”
Key stage 2
“Pupils should learn that sounds are heard because they travel to the ear...”
Key stage 3
“Pupils should study...how the ear works…Pupils should study the way sound is produced. They should have opportunities to investigate...the relationships between... pitch and frequency."

RELATED EXHIBITS
Model ears
These show the eardrums in our ears and how the sound is transmitted to the brain.
Vibrating string
A string vibrates to show standing waves which change in frequency with the note.

WHAT TO DO
Turn the knob to switch on the speaker and set the sound to a low note.

Q: What do you hear?
(A: You will hear the sound loudly and clearly.)

Turn the knob clockwise to make a very high note.

Q: What do you hear now?
(A: The sound may appear to be much quieter.)

Keep listening and turn the knob so you can no longer hear any sound.

Q: What frequency does the read-out show?
(A: For children this might be as high as 20,000Hz but for adults it will be a lot lower.)

MORE THINGS TO DO
Make a chart of highest note heard against age for all the pupils and teachers.

Q: Is there any relationship you can see?
(A: The chart should show a fairly close correlation with age.)

HEARING TEST: FURTHER INFORMATION

Interpreting sounds
Each different sound produces vibrations of a slightly different pattern. Our ears and brains detect these accurately to identify the source and many other characteristics of the particular sound. People don't just hear through their ears - they hear with their brains. A vibration, which can be transformed into the sound of a moderate rain, a rock lyric, or the blast of a chainsaw, is first picked up by the ears and then "read" by the brain.

Highest frequency audible
The ability to hear across a wide frequency range depends on the animal. These are top of the range audible by the average member of the species:

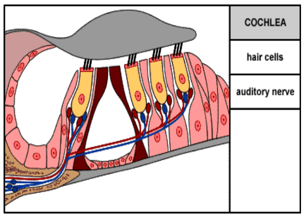
Humans	20000Hz
Dog	45000Hz
Cat	64000Hz
Mouse	91000Hz
Bat	110000Hz
Porpoise	150000Hz

Problems with hearing
Children will usually be able to hear the full range of frequencies in this exhibit, but older people will experience difficulties with the higher end. (Some shops now play irritating sounds at high frequencies which older people can not hear, to drive away groups of youths hanging around.)

The ear can be permanently or temporarily damaged by various causes. The inner ear is the most vulnerable, and can be affected by various illnesses, long-term exposure to loud noise or old age. Excessive noise exposure is one of the leading causes of hearing loss. Whether you're a musician, industrial worker, pilot, sports car racer, motorcyclist or anyone else exposed to excessive amounts of noise, your ears are paying the price. The tiny hair cells in the inner ear are easily damaged by loud noise and once you lose them, they never grow back.

Age-related hearing loss
This is called presbycusis and is the slow loss of the ability to hear high frequencies, which occurs as people get older. It occurs when the tiny hair cells inside the cochlea which pick up sound waves and transform them into nerve impulses are damaged or die - a common occurrence as people age. We are born with a set of sensory cells, and at about age 18 we slowly start to lose them. Hair cells do not regenerate. That's why most hearing loss is irreversible.

Cross-section of cochlea



But because age-related hearing loss progresses so slowly, most people don't notice any changes until well after age 50. The younger generation, increasingly exposed to loud leisure noise, may well reach the condition of 65 year-old at 30, and a 90 year-old at 50!

Cocktail party syndrome
Focusing on one speaker in a crowded or noisy environment is often especially difficult for a person with hearing loss. Social occasions are often difficult for such a person. Background noise, such as music or group conversations, can become overwhelming, making it impossible to participate in a conversation. Focusing on the lip movements of the person speaking and cupping your hand behind your ear can help a little.

VIBRATING STRING

Sound can vary in pitch
Low notes have long waves, high notes have short waves

DESCRIPTION
The exhibit has a loud speaker attached to one end of a tube and a string is stretched between the loud speaker cone and the other end. The speaker can be tuned by means of a knob to sound a range of low-pitched notes. At certain frequencies the string settles into a pattern of standing waves.

CURRICULUM LINKS
Key stage 1
“Pupils should have the opportunity to experience the range of sounds in their immediate environment and to find out about their causes and uses.”
Key stage 2
“Pupils should learn that sounds are made when objects vibrate, and investigate how sounds are changed in pitch...by changing the characteristics of the vibrating object, for example...the way it is made to vibrate."
Key stage 3
“Pupils should study the way sound is produced. They should have opportunities to investigate...the relationships between... pitch and frequency."

RELATED EXHIBITS
Sound patterns
This shows the wave pattern of you speech.
Hearing test
You can test your ability to hear higher frequencies.

WHAT TO DO
Turn the knob to sound the note.

Q: What do you hear?
(A: You will hear a low vibrating note.)

Q: What happens to the string?
(A: It is shaken back and forth.)

Turn the knob to change the pitch of the sound and watch what happens to the string. Try to ‘tune’ in the sound so the string vibrates in a steady pattern.

Q: Can you count the number of waves in the string?
(A: You should be able to tune it to show one, two, three or four wave patterns.)

Q: Do the higher pitched notes have shorter waves?
(A: Yes. And there are more of them along the string. They have a higher frequency.)

Try to tune the note to make all the standing wave patterns from one wave up to four or even more.

OTHER THINGS TO DO
Try blowing over the top of a bottle. This can create a standing wave and produce a sound. Wind instruments rely on this effect – the holes in the tubes create a different length of vibrating air and therefore a different note.

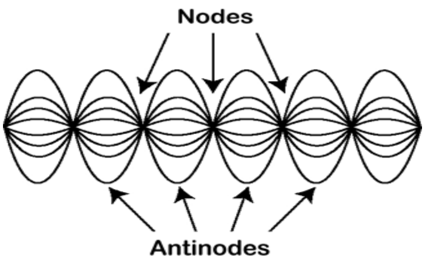
VIBRATING STRING: FURTHER INFORMATION

Sound waves

Sound is a wave, shown in the vibration of the string attached to a loudspeaker. The vibrations pass along the string, bounce off the other end and pass back again. If the waves are in step, a pattern of 'standing waves' is set up.

Nodes

The areas between the waves - 'nodes' - do not move. Sounds of different pitch have different wave lengths – the more nodes, the shorter the wavelength and the higher the note. Heavy lorries passing your house sometimes produce a booming in the room. This is caused by the shape of the room matching the pitch of the noise. The standing wave in the room means the air is resonating at that particular pitch.



Blowing over the top of a bottle can produce a standing wave and therefore a note depending on the length of the bottle. Wind instruments rely on this effect – the holes in the tubes when fingered create different lengths of vibrating air and therefore different notes.

Sound is a series of compression waves that moves through air or other materials. These sound waves are created by the vibration of some object, like a radio loudspeaker. The waves are detected when they cause a detector to vibrate. Your eardrum vibrates from sound waves to allow you to sense them. Sound has the standard characteristics of any waveform.

DELAY PHONE

The brain has to interpret the sounds we hear to make sense of them
The brain can be fooled by some sound

DESCRIPTION

An old-fashioned telephone has been adapted so that it plays back your voice after a short delay. You hear your voice as an echo. Most people find it difficult to carry on speaking. Some people find they start stuttering. You can change the length of the delay by pressing buttons.

CURRICULUM LINKS

Key stage 1
"Pupils should have the opportunity to experience the range of sounds in their immediate environment and to find out about their causes and uses."
Key stage 2
"Pupils should learn that sounds are heard because they travel to the ear..."
Key stage 3
"Pupils should study...how the ear works"

RELATED EXHIBITS

Model ears
These show how sound travels from our eardrums to the brain.
Tube tangle
A delay between speaking and hearting can be created using a very long tube.

WHAT TO DO

Pick up the phone and try saying a few words. If you cannot think of anything to say try reciting a poem or nursery rhyme.

Q: What do you hear?
(A: You hear your own voice played back though the earpiece after a short delay.)

Q: Do you find it difficult to carry on speaking?
(A: Probably you will.)

Try altering the length of delay using the dial at the front. Start with a very short delay.

Q: Is it easier to carry on speaking now?
(A: Most people are not too put out if the delay is very brief.)

Try again but with a much longer delay.

Q: Is this any easier or harder?
(A: It depends. You'll probably find there is one particular length of delay which is worse for you, but this could be different for other people.)

DELAY PHONE: FURTHER INFORMATION

Delays in hearing your own voice

Your brain is used to hearing your voice instantly or at least with a very short delay. When there is a delay of ¼ second or more your brain becomes confused and most people cannot continue speaking for more than a few moments. The confusion is due to hearing your voice through the bones in your head as well as the delayed voice through the telephone. The brain assumes there is a fault and shuts off the voice. Some doctors think this might explain why some people stutter – possibly due to a short time delay in the brain's processing the sound.

It is easier to continue when reciting a rhythmic verse or singing a song. This is because you are using different parts of the brain which are less dependent on the feedback from your ears.

Early phones had this problem. A caller could hear an echo of his voice coming back from the phone of the person he called. Echo cancellers had to be introduced to avoid this problem.

Stutterers

About 5% of children have some degree of stuttering but for most the condition disappears as they grow to adulthood. Only about 1% of the adult population suffers the affliction and most of these have learnt or been taught how to overcome or minimise the condition. During World War 2 Britain had both a King and a Prime Minister who were both stutterers. George VI never really coped with his problem and remained a very poor public speaker, while Churchill overcame his condition to become the finest orator of his day. The other great speaker of the time was Nye Bevan who also had a stammer. A surprising number of actors from Marilyn Monroe to Bruce Willis have the condition. It seems learning to cope with a problem brings confidence.

Delays when hearing others

It can also be disconcerting when trying to have a conversation when there is a delay between one speaking and the other hearing. We are used to short pauses and quick responses in normal dialogue. Over great distances, e.g. phoning a call centre in another country about a service, the delays can be frustrating.

Echo tube

A delay in hearing what you have produced can be induced by using a very long tube. As in the **Tube tangle** exhibit the sound is reflected internally and travels along the inside to the other end. At our Science Centre at Herstmonceux we have a tube arranged in a large coil with both ends close together. Slap the end of the tube and the sound is transmitted round the tube emerging after a short delay at the other end. This sound is also transmitted round the tube as an echo. The process continues until the sound is too attenuated to continue.

SPEECH PATTERNS

This electronic device shows sound waves
Different sounds produce different wave patterns

DESCRIPTION
The exhibit consists of a computer and a microphone. Speaking into the microphone produces a pattern on the screen, representing the sounds made. Instruments can be used as well as the human voice.

The program is set to freeze the pattern of sound above a certain volume, on the screen temporarily.

CURRICULUM LINKS
Key stage 1
“Pupils should have the opportunity to experience the range of sounds in their immediate environment and to find out about their causes and uses.”
Key stage 2
“Pupils should learn that sounds are made when objects vibrate, and investigate how sounds are changed in pitch...by changing the characteristics of the vibrating object, for example...the way it is made to vibrate."
Key stage 3
“Pupils should study the way sound is produced. They should have opportunities to investigate...the relationships between... pitch and frequency."

RELATED EXHIBITS
Tea chest bass
The wave patterns produced in the string when plucked can be observed.
Vibrating string
The wave patterns produced in the string change when the note from the loudspeaker changes.

WHAT TO DO
Speak into the microphone and look at the screen.

Q: What do you see?
(A: A wavy pattern on one of the coloured lines that stops when you stop talking.)

Q: What happens if you talk or sing in a high voice?
(A: The waves get shorter.)

Q: What happens if you talk or sing in a low voice?
(A: The waves get longer.)

Q: When no one is using the other microphone and you are talking, what do you see on the other line?
(A: A very small wave. The other microphone picks up a bit of your sound.)

Q: What happens if you talk or sing in a loud voice?
(A: The sound pattern is frozen for a time on the screen.)

Q: Does you voice produce different patterns from other people?
(A: Yes - everyone produces their own pattern on an oscilloscope though you would need to record over a length of time to see it clearly.)

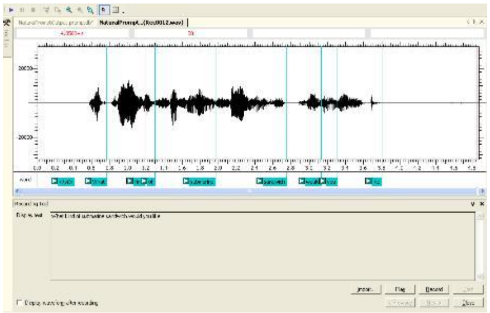
Q: Who could make use of voice patterns?
(A: The police can use this fact to tell whose voice it is on a recording.)

MORE THINGS TO DO
Try saying different letters of the alphabet and look at the patterns.
Try using other materials to create sound. Tap on a piece of wood or a book with a pencil.

SOUND PATTERNS: FURTHER INFORMATION

Speech patterns
The microphone detects the sound of your voice, sending it to the computer which converts it into a digital signal. It then displays this on the screen. If you sing a low note the screen shows a longer wave shape than a higher note. Relate this to the vibrating string. Particular letters, for example A and H show up as different-shaped patterns.

Voice recognition
Everyone's voice is made up of a variety of sound waves that can be distinguished from any other voice using such a machine. The police can use this characteristic to distinguish between voices on a tape or a phone tap.



Many computers can now be trained to understand speech and can convert your spoken words into written text. Once trained to understand your voice they will not respond to a stranger. Such devices are used to activate 'call home' phoning, to activate messages.