

Unit 8L Sound and hearing

About the unit

In this unit pupils:

- build on their knowledge of sound and hearing
- explain how sound travels through media
- give an explanation of how the ear works, find out about the harmful effects of loud noise and how loud noise can be reduced

In scientific enquiry pupils:

- decide on a suitable question to investigate and on what type of data to collect
- identify relevant variables and consider how to control or take account of them
- evaluate data, considering alternative explanations
- investigate the loudness of sounds using an appropriate strategy

Note

Hearing-impaired pupils can make a valuable contribution to this unit, but will need particular support, *eg by visual demonstrations of vibrations when sounds are produced, the use of amplification apparatus or ICT to translate sound into visual information*. The work at the end of the unit on hearing impairment can be adapted if there are hearing-impaired pupils in the class, to ensure their contribution is valued by the rest of the class.

This unit is expected to take approximately 8.5 hours.

Where the unit fits in

This unit uses ideas developed in key stage 2. It builds on unit 5F ‘Changing sounds’ in the key stage 2 scheme of work.

This unit could be linked with unit 7 ‘Measuring physical data’ in the ICT scheme of work, which suggests an investigation of an aspect of sound.

The elements of musical sounds are covered in unit 3 ‘Soundscapes’ in the music scheme of work.

The wave nature of sound is further developed in key stage 4.

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: identify patterns in qualitative data about sound and describe sound qualities; frame a question about hearing which can be investigated; identify and control key variables; identify limitations in their data; compare sound levels, and report on a loudness enquiry; describe a current issue related to sound

some pupils will not have made so much progress and will: measure sound levels and describe a range of sounds; describe what they found out from an investigation into hearing; compare sound levels, and report on loudness of sound in common situations

some pupils will have progressed further and will: select an appropriate approach to investigating a question about hearing; present a reasoned argument about a current issue in the science of hearing

in terms of physical processes

most pupils will: relate changes in pitch and loudness of sounds to changes in vibrations; explain how musical instruments can make these changes and relate these to the oscilloscope representations of waves; recognise that sound needs a medium to travel through and that it travels at different speeds through different media; explain simply how the ear works and give examples of hearing ranges; describe ways in which hearing can be impaired and how noise pollution can be reduced

some pupils will not have made so much progress and will: relate sound to vibration and identify a range of sources or vibrations; recognise that sound travels but cannot travel through a vacuum; explain that sound waves cause our eardrums to vibrate and that this enables us to hear; state that loud sounds can damage hearing

some pupils will have progressed further and will: relate pitch to frequency of sounds and loudness to amplitude; use particle theory to explain how sound travels through materials; use a model of the ear to discuss possible causes of hearing impairment

Prior learning

It is helpful if pupils know:

- that sounds are produced by vibrating sources
- how the sounds produced by musical instruments can be changed

Health and safety

Risk assessments are required for hazardous activity. In this unit pupils:

- use sound sources which could exceed recommended safe levels
- may work near traffic and require supervision

Model risk assessments used by most employers for normal science activities can be found in the publications listed in the *Teacher's guide*. Teachers need to follow these as indicated in the guidance notes for the activities, and consider what modifications are needed for individual classroom situations.

Language for learning

Through the activities in this unit pupils will be able to understand, use and spell correctly:

- words and phrases describing features of sound, *eg loud, soft, quiet, high, low, pitch, noise pollution, temporary deafness*
- words to describe sound vibrations, *eg frequency, amplitude, wave*
- words with different meanings in scientific and everyday contexts, *eg quiet, soft, low, pitch, wave, loudness, volume, dynamics*
- words and phrases relating to scientific enquiry, *eg qualitative data, alternative explanations*

Through the activities pupils could:

- understand information that is not explicitly stated or that the reader is assumed to understand

Resources

Resources include:

- musical instruments (actual and illustrations of), *eg stringed, wind, percussion*
- means of generating, capturing and displaying representations of sound waves, *eg tuning forks, signal generator, microphone, loudspeaker, oscilloscope, datalogger, or computer with sound card*
- radio or audio tape player
- data about sound levels, *eg from the Noise at Work regulations*; data about hearing loss in different age groups and accounts of temporary deafness or tinnitus

Out-of-school learning

Pupils could:

- think about how the musical instruments that they play or listen to make sounds
- think about the loud and distracting noises in the environment
- consider the effects of loud noise on hearing
- look for safety signs and warnings about loud noises
- ask family members or friends who play traditional instruments to demonstrate them

How are different sounds made?

<ul style="list-style-type: none"> to use appropriate language to describe different sounds that sounds are made as a result of vibrations 	<ul style="list-style-type: none"> Review pupils' knowledge and understanding of sound. Play an audio tape of different sounds, and ask pupils to identify and/or describe them. Check they use associated words correctly, eg <i>'high' and 'low' to describe pitch, and 'loud' and 'soft' to describe intensity</i>. Ask pupils how sound is produced. Show pupils examples where the vibration is easily seen, eg <i>tuning fork and polystyrene ball, loudspeaker and grains of sand</i>. Provide familiar sound sources or pictures, eg <i>musical instruments</i>, and ask pupils to identify which part(s) vibrate(s) to make the sound. 	<ul style="list-style-type: none"> describe different sounds using appropriate terms, eg <i>high, low and soft</i> explain that sounds are made as a result of vibrations and identify the source of vibration in a range of cases 	<ul style="list-style-type: none"> This activity is intended to help teachers find out what pupils know and understand about sound from key stage 2. Some pupils may confuse the use of sound words, eg <i>low for soft, and high for loud</i>. Working through examples to reinforce the concepts of pitch and intensity may be required to overcome this. In music the loudness (volume) of a sound is one of the elements, called the 'dynamics' of the sound. The opposite of loud is quiet; soft refers to the quality or timbre of the sound.
<ul style="list-style-type: none"> how to change the pitch and loudness of sounds from musical instruments to describe patterns in qualitative data and make generalisations from these to relate changes in sound to changes in vibrations 	<ul style="list-style-type: none"> Demonstrate, eg <i>with a guitar, recorder and drum (adjustable tension)</i>, how notes of different pitch and loudness can be made. Ask pupils to investigate differences in the vibrations that produce the sounds in musical instruments, and help them to make generalisations. Reinforce these ideas by showing how pulling down further on a mass suspended from a spring makes the oscillations bigger, and how using a larger mass makes the oscillations slower. Discuss with pupils how these observations relate to their work on sound-producing vibrations. 	<ul style="list-style-type: none"> suggest ways to change the pitch and loudness of sounds from musical instruments make generalisations about changing sounds in musical instruments, eg <i>the thinner the string, the higher the sound</i> make generalisations about changing sounds related to vibrations, eg <i>the greater the movement, the louder the sound; the faster the movement, the higher the sound</i> 	<ul style="list-style-type: none"> Pupils who play a musical instrument could be asked to demonstrate it to the class. The use of instruments from a variety of cultures, eg <i>sitar, tabla, pan pipes</i>, provides an opportunity to broaden the range of evidence about changing sounds in musical instruments.

Learning objectives

Pupils should learn:

- to use appropriate scientific language to describe features of a sound wave
- that sounds with high pitch have a high frequency
- that sounds with a high amplitude are loud
- to relate their results to scientific knowledge and understanding

Possible teaching activities

- Extend pupils' ideas about sounds and vibrations using an oscilloscope connected to a signal generator (or a microphone connected to a datalogger) to present a 'picture' of a sound wave. Explain that the wave on the screen is a representation of a sound wave. Introduce and explain the terms 'amplitude' and 'frequency', and relate these to loudness and pitch of a sound by demonstrating how the wave form changes with different sounds. Provide representations of different sound waves and ask pupils to identify, *eg the loudest, lowest*.

Learning outcomes

Pupils:

- use the terms 'frequency' and 'amplitude' in describing sound waves
- relate high pitch to high frequency and high amplitude to loudness
- compare and interpret wave forms in terms of pitch and loudness

Points to note

- A brief account of what is happening in the oscilloscope is all that is needed at this point, if pupils are not to be distracted by the details of the display system. Pupils may use an oscilloscope to study the features (elements) of sounds in unit 3 'Soundscapes' in the music scheme of work.
- A detailed account of the longitudinal nature of sound waves is left until key stage 4. At this stage you will need to make sure that pupils have not gained the erroneous idea that sound waves are transverse. A quick demonstration using a slinky spring might be helpful.
- Extension: show pupils the wave representation produced by different sources of sound, *eg tuning forks, musical instruments*, and ask them to identify and try to explain similarities and differences.

Pupils should learn:

Pupils:

How does sound travel through solids, liquids and gases?

- how the vibrations that make sound are transferred through a medium
- that sound cannot travel through a vacuum
- to relate sound travelling through a medium to the particle model
- that sound travels at different speeds in different types of material
- to use the particle model to explain how sound travels
- Establish that sound needs a medium to travel through. Show pupils an electric bell ringing inside a bell jar. Ask them to predict what will happen if the air is pumped out of the jar, and test their predictions. If the pump is noisy, it would be better to listen as air is let back in.
- Ask pupils whether sound travels through solids, *eg Can you hear through closed doors? Can animals hear under water?* Ask pupils to carry out some quick activities to demonstrate transmission of sound through solids and liquids, *eg battery-operated radio in sealed plastic bag under water using a hydrophone, sound passing through a wooden bench, a length of metal rod, a string telephone*. Help pupils to make comparisons with sounds from the same source transmitted through air and establish that transmission is more effective through denser media. Ask pupils why this may be so, reminding them of the particle model of solids, liquids and gases. Help pupils to record what they found out, *eg using annotated diagrams*.
- Remind pupils that sound travels much more slowly than light, *eg fireworks*. Ask them if sound travels at different speeds in solids/liquids/gases. Draw on experiences, *eg singing railway lines before the train is heard through air, listening closely with an ear to a metal railing that is tapped some metres away*. Ask how they might measure these differences. Quote the example of the two people who, some 100 years ago on Lake Geneva, measured the speed of sound in water. One made a visual signal while striking a bell under water. The other started his stopwatch and plunged his head in the lake until he heard the bell.
- Encourage pupils to explain the differences using the particle model.
- state that sound cannot travel through a vacuum but can travel through solids, liquids and gases
- describe how sounds travel through solids, liquids and gases
- explain in terms of the particle model why sound needs a medium
- explain how sound travels at different speeds in different types of material
- explain everyday phenomena in terms of the different speeds at which sound travels in air and solids
- Sound waves dissipate less energy when travelling through liquids and solids, compared with air. This allows them to travel more quickly and to retain intensity.
- Sound travels at 330ms^{-1} in air, 1500ms^{-1} in water, and at higher speeds in solids: 3000ms^{-1} in brick and 5000ms^{-1} in iron.
- Unit 7G 'Particle model of solids, liquids and gases' and unit 7H 'Solutions' introduce pupils to the particle model.
- Unit 9K 'Speeding up' covers the measurement of speed. Pupils could measure the speed of sound as part of that unit.
- Extension: Pupils could make a hydrophone by stretching a thin sheet of rubber over the open end of a funnel connected to a length of rubber tubing.

Checking progress

- to give explanations in answer to questions
- With the class, produce a list of key questions related to the work that has been covered. Ask pupils in groups to use secondary sources and their own notes to produce answers to five of these. Pick out any particularly challenging questions and discuss pupils' answers to them with the class.
- use appropriate terminology, evidence and reasons in their answers
- CD-ROMs on sound would be useful for the review of the work in this section.

How do we hear sounds?

- that different people can hear different ranges of pitch
- that hearing changes with age
- that some animals detect sounds that are inaudible to human ears
- Use an audio signal generator to generate a range of sounds of different pitch. Ask pupils to indicate when they can no longer hear the sound. Tell pupils about the range you can hear and ask why the teacher's range of hearing is often more limited than that of pupils.
- Ask pupils what they know about the hearing range of animals and discuss how different animals use sound, *eg long-distance communication in whales, ultrasonic echo location in bats, communication using whistles with dogs*.
- describe how hearing ability changes with age and that hearing can be damaged
- describe examples of animals detecting sounds that are inaudible to human ears
- Sensitivity is needed in talking about hearing impairment. There is an opportunity for a visit by an outside speaker concerned with the issues and problems faced by hearing-impaired people.
- The range of hearing for an adult is typically from 20Hz to 20000Hz, but pupils may hear as high as 30000Hz.

Learning objectives

Pupils should learn:

- that the energy of sound is transferred through the eardrum
- that the effects of vibration to the eardrum are transferred to the brain

Possible teaching activities

- Elicit ideas from pupils about how we hear sounds. Show them an anatomical model of the ear, illustrating the relative sizes of the parts and how they are connected.
- Explain how the eardrum vibrates as a result of sound entering the ear, and the transmission of vibrations to the inner ear. A model eardrum can be used to demonstrate the transmission of vibrations from the air to a membrane.

Learning outcomes

Pupils:

- identify the parts of the ear on a diagram or model
- describe, *eg by annotating a diagram*, how vibrations in the air are transmitted and translated into electrical signals, which pass to the brain

Points to note

- A full explanation of the working of the ear is not required. Work with pupils should concentrate on developing an understanding of the transmission of vibrations and their conversion to electrical signals, which pass to the brain.
- Make a model eardrum by removing the end of a plastic cup, and covering the hole left with clingfilm. The clingfilm will vibrate when you talk into the open end of the cup.

- how to frame a question that can be investigated
- how to decide whether measurements, qualitative observations, or data from secondary sources are appropriate
- to decide which factors in a particular investigation can be controlled
- to look critically at results and decide how strongly they show a relationship
- to compare their work with the work of others, and to evaluate it

- Ask pupils to design and carry out an investigation into an aspect of hearing, *eg*
 - *Are two ears better than one in detecting the direction sound is coming from?*
 - *Does the size of the outer ear affect hearing sensitivity?*
 - *Does hearing range decrease with age?*
- Help them to decide on a suitable question to investigate, and to plan their work, including consideration of variables, collection of suitable data and evaluation of results.
- Ask pupils to use overhead transparencies (OHTs) or a flip chart to summarise their work and to present it to other pupils. Encourage pupils to compare their own investigations with those of others and to identify good and bad points in them.

- decide on appropriate measurements to answer the question
- identify factors which need to be controlled if they are to make a fair test
- describe strengths and weaknesses in their work, *eg We tested four people in each age group, but the results don't show a clear pattern, so we need to test more people*

- Pupils could find data from secondary sources as well as collecting first-hand data.
- Extension: pupils could use secondary sources, including reference books, the internet and CD-ROMs, to find out about the use of sound in interesting or novel contexts, *eg how telephones or microphones work, how bats use ultrasound to navigate, how echo soundings are used by ships.*

Can sound be dangerous?

- how to compare loudness
- how to plan to collect data
- about reasons for repeating measurements
- to present data appropriately

- Raise issues of noise pollution, *eg near airports, due to traffic and listening to pop music*. Demonstrate use of a sound-level meter. Ask pupils about an alternative method of comparing sounds that relies on the way loudness diminishes with distance, *eg measure the distance at which the sound first can no longer be heard*. Ask pupils to investigate a question, *eg*
 - *survey the loudness of sounds at different locations around the school or over time in their own classroom*
 - *compare the loudness of sounds from personal stereos, eg set at the level at which pupils like to listen*
 - *investigate the effects of sound insulation, eg with a clock in a box filled with different absorbent materials*
- Help pupils to plan the measurements (including repeat measurements) they will take and the way they will record and present their data.
- Present data from secondary sources on sound and recommended safe levels. Ask pupils to draw up a list of sound levels for common sounds.

- use a sound-level meter or other method of comparing sounds
- make a sufficient number and range of measurements
- present data and draw appropriate conclusions

- The decibel (dB) scale measures differences between sound power levels. It is expressed logarithmically to reflect the ear's response. Sound-level meters use a modified scale called dB(A), which allows for the ear's different sensitivity to different frequencies. Strictly speaking, loudness is measured in phons, but at this level pupils can use the sound-level meter values as measures of loudness. A datalogger could be used with the meter for measurements over time.
- This work could be linked with unit 7 'Measuring physical data' in the ICT scheme of work.



Safety – supervision is required for any work near traffic. Follow employer's guidelines for fieldwork. Ensure sound levels are within permitted limits. Pupils' plans must be checked for health and safety before practical work begins

- to use their scientific understanding to interpret secondary sources on a current issue

- Present information about noise pollution and ask pupils to suggest ways of reducing noise levels.

- report on a topic showing understanding of the nature of sound and hearing

Learning objectives

Pupils should learn:

- to consider how strongly the data supports any conclusion drawn
- to consider alternative explanations
- how loud sounds can damage hearing
- to understand information that is not explicitly stated or that the reader is assumed to understand

Possible teaching activities

- Present pupils with information about hearing impairment, *eg among different age groups*, and ask them to suggest possible reasons, *eg exposure to loud sounds at work, exposure to loud sounds when young, inherited deafness*. Help pupils evaluate possible explanations and to think of reasons for supporting and rejecting them.
- Use some accounts of people's experience of temporary deafness or tinnitus to discuss with pupils what excessively loud sound can do to hearing. Use a model or diagram of the ear to discuss what might cause the problems.
- Ask pupils to present their findings and views in the style of a popular medium, *eg youth magazine, local radio item*.

Learning outcomes

Pupils:

- explain why they think the data supports one explanation more than another
- describe sensations of temporary deafness or tinnitus and indicate how these arise

Points to note

- Teachers will be aware of the need to be sensitive to individual pupils and to their families.
- The causes of tinnitus and temporary deafness are still a matter of debate, and probably involve both the ear and the brain. For details on current ideas search the internet, *eg*
 - www.hearnet.com
 - www.hhmi.org/senses/start
- Extension: pupils could be asked to find out about a range of questions, *eg how some rock musicians protect their hearing, about the career of Evelyn Glennie, the renowned deaf percussionist*, using an internet search, *eg 'hearing+loss', 'Evelyn+Glennie'*.

Reviewing work

- to relate ideas about sound and hearing to each other
- Review work on sound and hearing by helping pupils construct a concept map using terms, *eg pitch, loudness, amplitude, decibel, hearing, vibration, sound insulation*. Discuss outcomes with pupils.
- make connections between different ideas within this unit