PUPIL
RESEARCHER
INITIATIVE

On Air

Setting the Scene

You will be working as a scientist learning about the media by doing a placement in the Science Unit at STS Radio. Your assignment is to prepare a 4-minute feature about ultrasound and its uses for the series Science Alive. Using information from a variety of sources and conducting a real interview with an 'expert' (your teacher) you will prepare a script for the feature which will explain ultrasound to a non-scientific audience.

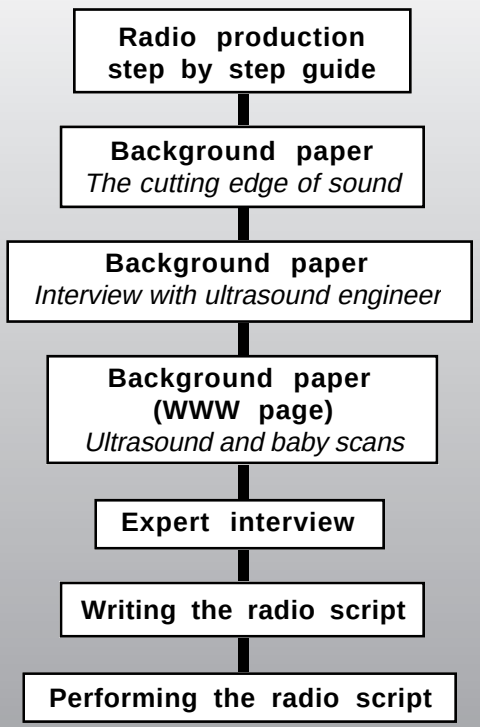
Pupil Research Brief

Study Guide

Syllabus Targets *Science you will learn about in this Brief*

- ❑ sounds are produced when objects vibrate
- ❑ the number of complete vibrations each second is called the frequency (hertz [Hz])
- ❑ the higher the frequency of a sound the higher the pitch
- ❑ electrical oscillations can be used to produce ultrasonic waves
- ❑ ultrasonic waves have a frequency higher than the upper limit of the hearing range for humans
- ❑ ultrasound has a wide range of uses in medicine and industry, e.g. in pre-natal scanning and cleaning of materials
- ❑ ultrasonic waves, like other waves, carry energy and can be reflected

Route through the Brief



Outcome Checklist

You will produce a script for a 4-minute feature on ultrasound and its uses for a radio programme. A step by step guide to radio production, two scientific papers, a WWW page, an interview transcript with an ultrasound engineer and a real interview with an 'expert' will help you plan and write the feature. You should make sure you produce the following items as you work through the Brief.

Background papers

- ❑ notes on ultrasound and its uses

Expert interview

- ❑ further information on ultrasound and its uses

Production script

- ❑ a 4-minute script for the radio programme feature

The cutting edge of sound

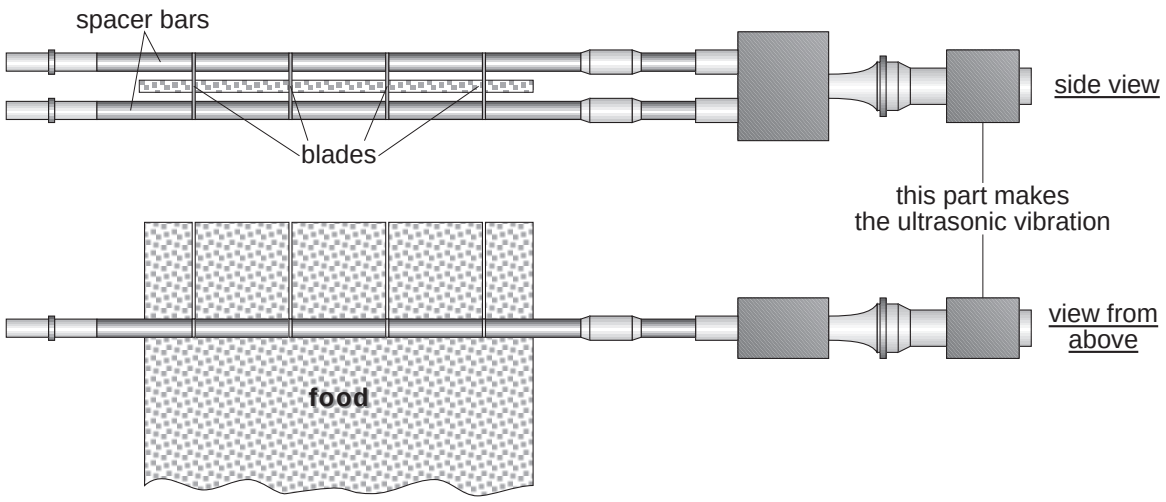
Researchers at Loughborough University have developed a new kind of knife for the food industry. It can cut through difficult materials like toffee and frozen fish without shattering them or wasting anything. The knife even cleans itself. It's all done with ultrasound, so the knife cuts its way through in complete silence.

Already, one of the world's largest food companies is running trials on an ultrasonic cutting system. A spokesperson commented, "We have been very impressed at how quickly and efficiently the device cuts through chocolate. It will allow us to manufacture a wider range of products in future."

The idea of using ultrasound to vibrate a blade at high frequency has been around since the 1950s. An electrical circuit generates the ultrasonic signals at just above 20 000 hertz. The signal is used to make a blade vibrate at 20 000 times per second, fast enough to cut through almost anything.

Unfortunately, early versions of the ultrasound knife were unreliable; they had a habit of self-destructing suddenly. Now, thanks to EPSRC's Mechanical Engineering Programme, a team of engineers at Loughborough have discovered how to control the power of ultrasound using 3-D computer models and laser holograms. Noisy food factories will soon be a thing of the past.

Figure 1. The ultrasound knife



food being sliced by the ultrasonic knife

INTERVIEW WITH ULTRASOUND ENGINEER

The engineer is Dr John Tyrer from Loughborough Universtiy. He is interviewed by researcher Kathy Sykes.

		Word count
Kathy	**Now John, you're one of the researchers who's been involved in inventing a new cutting knife. It's an ultrasound cutting device. What kind of things can you cut with it?**	**29**
John	Actually you've come at an opportune moment... biscuits, for example, and chocolate, are some of the major uses we're now finding for ultrasonic cutting. These are really beginning to come into their own because we're looking at process industries where people are interested in very efficient ways of cutting large stocks of material.	53
Kathy	**What else other than chocolate and biscuits can they cut?**	**10**
John	Just about anything. In the food industry, for example, they can go through nougat, meat, frozen fish, even ice cream. In other areas, paper, wood, ceramics and glass. We haven't yet been too successful in cutting metal, though there are other things we can do to metal.	46
Kathy	**So almost anything other than metal it seems.**	**8**
John	And metal, probably, but we haven't got there yet, sadly.	10
Kathy	**Now it's an ultrasound knife and that seems strange - somehow you're using sound to cut things. How does it work?**	**20**
John	Okay. Perhaps the term is a little misleading because what we're actually doing is using mechanical vibrations to cut with. In effect, shaking or vibrating the blade. The reason we call it ultrasound or ultrasonic cutting is because we're trying to operate the system in frequencies we can't hear, or we hope we can't hear. But unfortunately some of us can still hear these frequencies. So that's where the term ultrasonic cutting comes from because we're really using frequencies that are just beyond the audible limit of most people.	88
Kathy	**Is this ultrasound knife noisy?**	**5**
John	When we run it properly the answer should be no. And to most people, you can't actually hear what's going on. But unfortunately if we don't quite get it right we get all sorts of noises - spurious noises introduced by the system. And that's one of the problems.	48
Kathy	**Can we hear it?**	**4**
John	If you want to. But before you do so, I suggest you...	12
Kathy	**...I'll put on my protective ear defenders.**	**7**
John	So here we go. We're now operating just above 20 000 Hz	11

Kathy	**You can just hear a high-pitched squeak.**	**8**
John	A whistle. This is what happens when things start to go slightly wrong... (audible noise from machine)	13
Kathy	**So that kind of noise, when a doctor is operating, doing some surgery using one of your knives, shouldn't happen?**	**20**
John	That's right. We want it to be just a pure ultrasonic frequency. With the sort of systems we get involved in, we build up complex systems which have many different blades and many different elements. If you don't get it right, you get all sorts of little mini resonances occurring between all of these components. And they're the noises you can hear.	62
Kathy	**What's so great about this knife? What are some of the advantages of using it?**	**15**
John	One of the big advantages is that it's a very low friction form of cutting. If you imagine when you take a sharp knife and try and cut through paper, you feel the drag of the blade on the paper; and sometimes it doesn't cut properly. The paper will bind up underneath the blade. With an ultrasonic cutting knife, you actually find that the friction virtually disappears.	67
Kathy	**Now to go back to the food industry. You said you could use it for fish or for toffee or for something like that. Why use one of your knives instead of the methods they used before?**	**37**
John	Yes, that's quite a good question. Either it has to be cheaper or there has to be some other benefit. When cutting normally, one would use saw blades - rotary saw blades. Now with a saw blade, as you know if you cut through wood, you generate sawdust. If you imagine that you're cutting through frozen fish and these are prime fish steaks, and you've just paid a lot of money for this fish steak, you don't want to then start cutting through it and wasting some of your fish. So what we want is a cutting process where we can slice through, but we don't generate any waste. And that's the other major advantage of ultrasonic cutting.	117
Kathy	**So as well as making it cheaper because you're not wasting material, are there any other advantages of using it?**	**20**
John	It can be quicker. In fact, frozen fish is quite a difficult thing to cut anyway because, usually when they come off the ships, you have a large palette of frozen fish steaks and these things are very hard.	162

People who try and cut chipboard will very soon find out to their cost that flakes of the wood are very hard and brittle, and will wear away the blades very quickly. Well frozen fish is exactly the same. It's made up of lots of flakes of frozen fish, all at different angles, and they wear the blades out very quickly.

So a further advantage is that these blades are not physically sawing through the material, they're actually breaking the material up - they're cracking the material just ahead of the blade. So if we get it right the blades don't wear anything like as quickly as with conventional cutting. So the quality of the product will be there for a much longer time.

Kathy **Could people at home start using ultrasound knives in the kitchen? Or somewhere else?** **14**

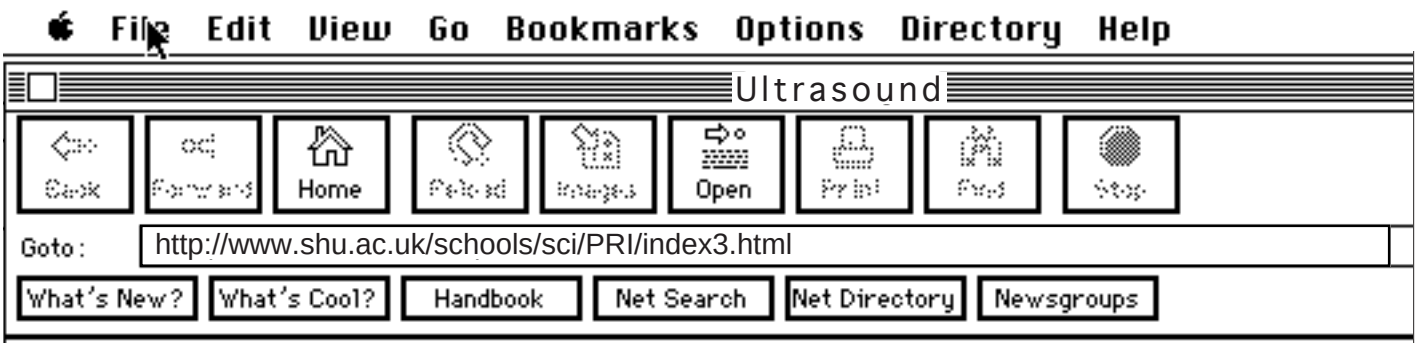
John Yes, it's an interesting thought. Right now the surgeons are beginning to use ultrasound knives in the form of ultrasonic scalpels. So if you imagine whilst a sharp knife will cut skin, if you're in a very, very detailed operation, you may not have the room to cut through with a blade. Here the ultrasonic knife can have great precision without needing any physical sawing motion. It's a way of having great control. 149

One of the other benefits though is that you can also generate a lot of heat in the blade. So that, not only can you cut through a blood vessel, you can also use it to cauterise, which is basically to heat-seal the blood vessel as well. And the future, well, high precision robots and virtual reality will enable surgeons to operate without worrying about their hands shaking.

Kathy **Are there any other uses for ultrasound apart from cutting?** **10**

John Quite a lot of modern plastic products are now welded together with an ultrasonic welder. What you do is again use this mechanical force to generate movement in one of the plastic surfaces. Very rapidly that heats up under friction with one of the other surfaces it's pushing against. The two meld together, so you don't need any glue. 59

Kathy **Excellent.**



Sound, ultrasound and baby scans

Sound

Wouldn't music be boring if it were played all on one note? Without a variety of different pitches, from bass to treble, it wouldn't hold our interest for long. But what makes the notes sound higher or lower? It's all to do with vibrations. Whether its the strings on a piano or guitar, or the air in a trumpet, something is moving back and forth - or vibrating. The faster something vibrates, the higher the note it produces.

Scientists use the word frequency instead of saying 'the number of times an object vibrates a second'. Frequency is measured in hertz. So if a guitar string vibrates two hundred times a second it has a frequency of 200 hertz, or 200 Hz.

Ultrasound

The human ear is incredible. It can detect frequencies from a deep, growling 20 Hz, all the way up to an ear-splitting 20 000 Hz (20 kHz). However, our ears are completely deaf to anything higher than 20 kHz. So any frequency of sound above that isn't really sound at all, its called ultrasound.

It's different for many animals. We know cats can hear frequencies up to 65 kHz and that bats chatter away ultrasonically. Not only that, by firing out bursts of ultrasound waves and picking up the echoes, bats can hunt insects in complete darkness.

Baby scans using ultrasound

How can a doctor check if a baby is growing properly in its mother's womb? Not with X-rays which are much too dangerous, but with ultrasound. Very high frequency ultrasound can actually pass through the body. Every time it meets new layers inside, like the womb or a baby's head, a little bit is reflected. The echoes are picked up by a sensor connected to a computer. The computer can then display a live television picture of the baby. Doctors also use ultrasound scans to detect cancers and heart problems.