5.1 Writing a summary

Briefing sheet 1

Your task is to write a summary of information from three different sources. Your teacher may give you a topic, or tell you to choose your own. This briefing sheet will help you to choose some questions to investigate.

Part 1 Selecting questions to find out about

1 Select your questions before you look at any sources of information. Write down a few questions (six to eight) you would like to find out about. These should include general questions about the topic, as well as those relating to your A Level subject.

2 Which sources of information are you going to use? Be as specific as you can – do not just say 'textbooks' or 'the Internet', but give some idea of which books or websites.

3 When carrying out the research task, you will need to make notes based on what you find in your sources of information. This activity is an opportunity to practise skills learned through other LSS activities, such as reading and representing text using visual methods.

5.1 Writing a summary

Briefing sheet 2

Part 2 Writing a summary

This is a guide to the process of writing your summary.

As always, it is good practice to write a first draft. You could record your findings under the following headings before starting this.

1 Title of summary

2 Short introduction explaining why your questions are important, and how they relate to the topic.

3 Short explanation of how you found out the information and where you looked.

4 What are your conclusions about what you have learned?

The final draft of your summary should be in the following format:

Length:	1 page of A4 (no more than 500 words)
Font:	Arial
Title:	16 point font, bold, centred
Name of author(s) and institution:	12 point font, italicised, aligned left (this is you and your school)
Summary text:	12 point font, aligned left

5.1 Writing a summary

Briefing sheet 2

It is important to stick to the format specified, as many scientific publications and journals ask that articles are submitted in a particular format. In some cases, articles may be rejected if they are in an incorrect format.

5 Create a template in Word or another word-processing package to conform to this format. Save the template so you can use or adapt it in future. Send your work to your teacher electronically so they can check your template, or use other members of your group to review this work.

5.1 Writing a summary

Applied science resource 1

Will and Deni McIntyre/SPL

DAMIAN MURPHY

Hearing the world

In your GCSE science course you will learn about how sound waves are affected by their surroundings as they travel. Engineers are using this understanding to develop highly-realistic sound systems for films, music systems and computer games. The same ideas can help people with eyesight and hearing problems. Damian Murphy of York University describes how this is done.

GCSE key words
Sound waves
Reflection
Diffraction

Stereophonic sound has been around for over 30 years, and multi-speaker techniques are now commonplace in cinema sound systems, home cinema and DVD systems. They give a more 'immersive' feel to the sounds you hear. Your PC may have surround-sound enhancements for games and other entertainment software. This 'three-dimensional audio' can also be produced using standard headphones or stereo speakers together with precise measurements of the detailed physical characteristics of a person's head and ears.

For accurate surround-sound two things need to be taken into account. First, the environment in which it is heard — a room, a corridor, the middle of a field — affects the quality of a sound, and we need to be able to understand and recreate this. Second, our hearing system is designed to give us information about where a sound is coming from. This is a basic survival mechanism enabling us to run away from sounds associated with danger (e.g. a stampeding woolly mammoth, or an approaching fast car). Our sense of direction is very finely tuned, and for convincing surround-sound we need to know more about how our ears give us this directional information.

IMPULSE RESPONSE OF A ROOM

The size, shape and materials of a room all play a part in the quality of any sound heard within it. Imagine a gun being fired inside a large room or hall. This short, sharp and very loud event causes variations in the air pressure (known as **compressions** and **rarefactions**) that are transmitted through the air itself, spreading out into the room in every direction — a **sound wave**.

Figure 1 shows how a sound wave travels across a room. When it strikes objects in the room, it is

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Applied Science resource 1

around us

partially **absorbed** and partially **reflected.** There may also be **diffraction** effects, where the sound bends round an object or passes through a gap (such as an open door), resulting in further spreading of the original sound wave. It is because of diffraction that we can hear through an open door or window. Very quickly (within 100 ms) the sound from our gunshot has spread through the room, having been reflected, absorbed and diffracted, resulting in a very complex and random pattern of sound.

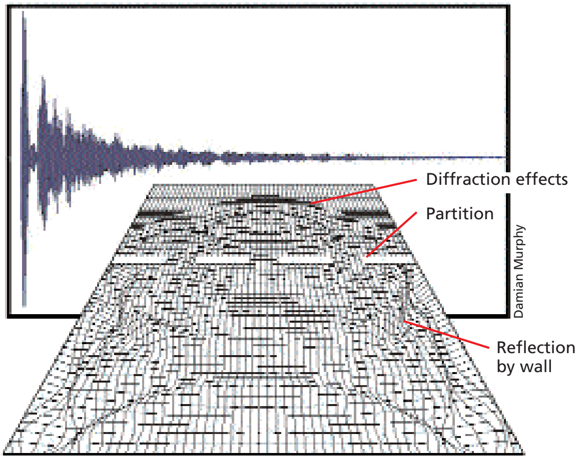


Figure 2 A sound wave caused by the computer equivalent of a gunshot propagating through a mesh structure that is designed to simulate a room. Notice the reflections at the boundaries and the diffraction effects in the partitioned area, caused by gaps in the dividing wall. In the background is a typical room impulse response obtained from such a model.

MEASURING SOUND

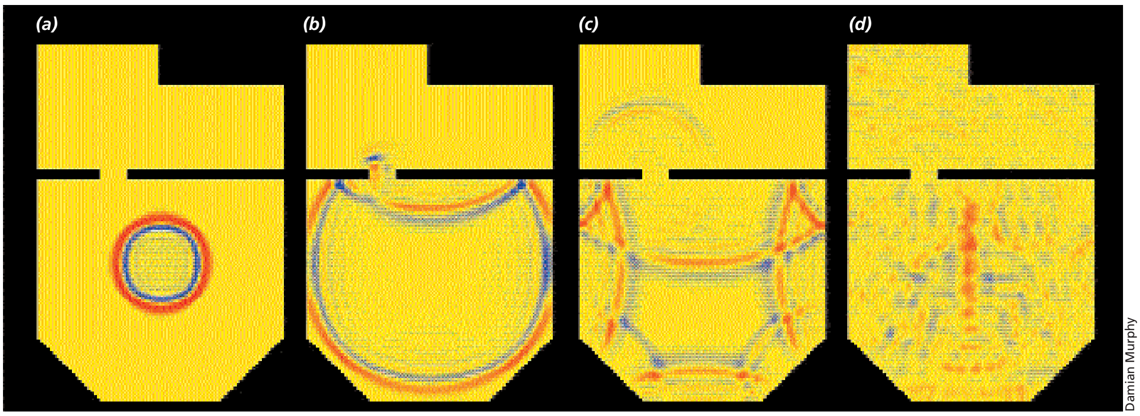
The example of a gunshot sound is used because it contains all the audio frequencies in which we are interested at equal amplitudes. We can describe the complex way the room affects this sound using a single measurement called the **impulse response**. We measure the variation in air pressure using a microphone (or just by listening to the sound) at a point in the room. We can examine how each frequency has been changed by its interactions with the room.

The impulse response itself is not very interesting to listen to. It lasts anywhere between 0.1 and 10 seconds depending on the size of the room and how reflective the surfaces are, and sounds like a click with a prolonged and decaying tail. This decaying part of the impulse response is due to the **reverberation** present in the room and is the characteristic 'hanging on' quality of a sound that can be heard once the sound source itself has become silent. Reverberation can, for example, be heard quite clearly in an empty church. It is possible to take this very boring sound and combine it electronically with any other sound — for example, a piece of music. We can make the music sound as though it is coming from inside any particular space, as long as we know the impulse response of that environment.

The impulse response of a room can be measured directly, but for most applications it is more practical to calculate an approximation using an acoustic model. Figure 2 (above) shows how the acoustics of a room can be modelled using a computer simulation.

- **Most pop music vocal recordings take place in small rooms or booths yet the results we hear on a CD have a very different acoustic characteristic. What do they sound like? Why do you think this is?**

*Figure 1 **(a)** A sound wave spreads out into the room. **(b)** It is partly reflected and partly absorbed by the walls. **(c)** It is diffracted as it passes through a doorway into the room beyond. **(d)** After a while, both rooms are filled with a random jumble of low-amplitude sound waves.*



5.1 Writing a summary

Applied Science resource 1

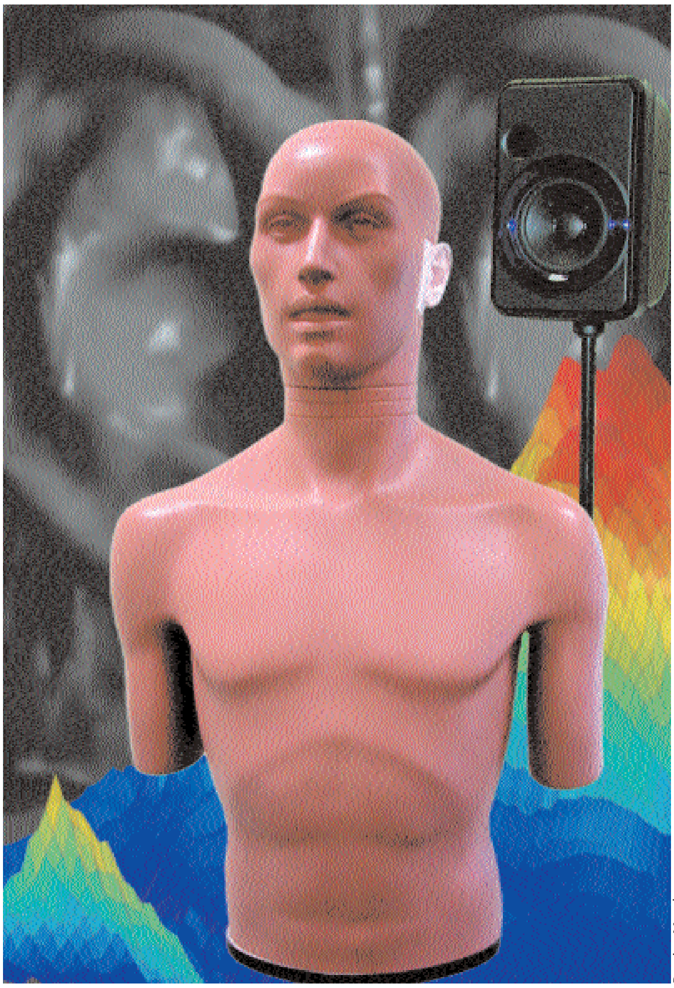


Figure 3 A mannequin and speaker used in the measurement of the head-related impulse response. A dummy is often used because it stays still when the measurements are being made. In the background is a three-dimensional graph of the measured head-related impulse responses showing how frequencies vary with the direction of the sound, and also a model of the outer ear.

Some owls have one ear higher than the other. This is thought to give them a better three-dimensional picture of the sounds around them in a dark wood.

IMPULSE RESPONSE OF THE EAR

Just as the room around us affects the sounds we hear, so does the shape and structure of our head, but on a much smaller scale.

A sound coming to us from one side arrives at one ear slightly before the other and its amplitude is different at each ear. Sound waves diffract around the head, and undergo minute reflections in the pinnae (the fleshy parts of the outer ears). This alters the frequency content of the sound that reaches the ear-

- **Next time you go to the cinema, listen carefully to the sound you hear around you. What can you hear from each set of speakers? How good is the surround-sound effect?**

Damian Murphy with the mannequin head.

drums and is how we know which direction the sound has come from.

Every person's head affects sounds in its own way because we all have heads and outer ears of different sizes and shapes.

If we measure the room impulse response at the entrance to the listener's ears we can find out how sounds are affected by both the room and the listener's head and ears. It can be electronically combined with any audio source. A sound can then be placed at any position in a three-dimensional virtual space around the listener's head, and reproduced using only headphones (or stereo speakers) (see Figure 3).

THE GOAL

Sound research can be valuable in producing aids for both visually and hearing-impaired people, for example:

- improved hearing-aids;
- audio guides for popular tourist attractions;
- computer interfaces that translate visual information into a virtual surround-sound space by placing 'audio icons' around the listener's head.

The ultimate scientific goal in surround-sound is to electronically generate a complex three-dimensional acoustic world that is indistinguishable from what we normally hear around us. As well as work with the visually impaired, this technology has applications in music composition, sound reproduction, art, architectural design, cinema, telecommunications, user-interface design, television and gaming entertainment. The result is accurate, exciting surround-sound effects.

Damian Murphy is in the Department of Electronics at the University of York.

5.1 Writing a summary

Applied Science resource 2

Adam Gibson

Left: *Coloured three-dimensional computed tomography (CT) scan of the heart and its blood vessels*

GCSE key words
Electromagnetic spectrum
Radio waves
Microwaves
Infrared radiation
X-rays
Gamma rays

X-rays are produced by X-ray machines or linear accelerators; gamma rays come from radioactive sources.

Microwaves, infrared, ultraviolet and X-rays are all electromagnetic waves. Why are some used to create medical images and others to treat disease? Here, we focus on how the electromagnetic spectrum is used by medical physicists to create images of body organs. In the next issue, we will look at how radioactivity is used in diagnosis and therapy.

Most people have had an X-ray. It might have been at the dentist's or to identify a broken bone. X-rays are particularly good at generating images of teeth and bones because they cannot pass easily through the calcium in these hard tissues. Bones and teeth absorb X-rays more than soft tissues, such as muscle and fat, so they show up on an X-ray image as shadows. In the 110 years since X-rays were discovered, they have become an important tool for doctors.

Left: *This fuzzy image is the first medical X-ray picture. It was taken by Professor Wilhelm Röntgen in 1895 and is an image of his wife's hand. The bones of her hand and her wedding ring absorb X-rays strongly so they show as a shadow in the image*

5.1 Writing a summary

Applied Science resource 2

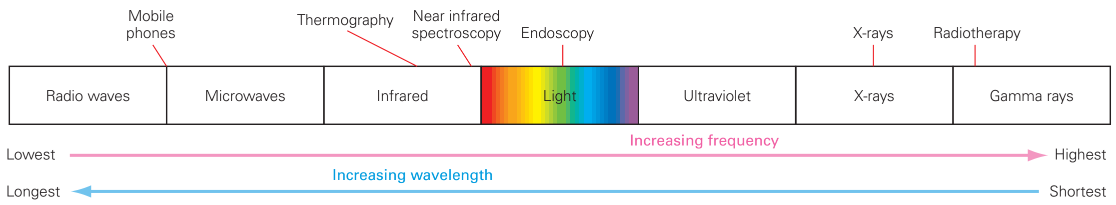


***Figure 1** The electromagnetic spectrum*

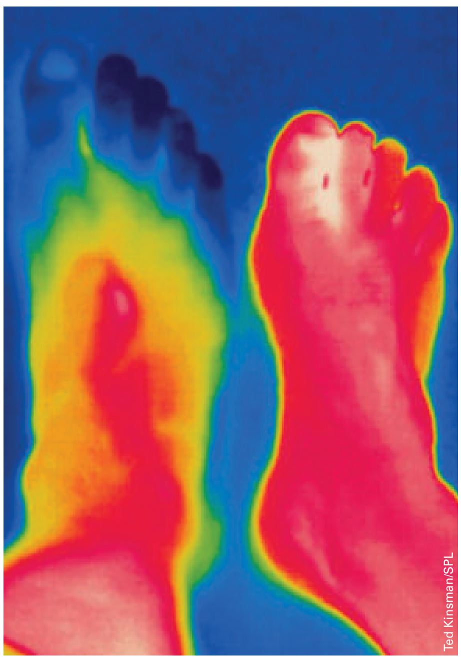
More recently, other parts of the electromagnetic spectrum (Figure 1) have been used by medical physicists to investigate the body (**diagnosis**) and to treat illnesses (**therapy**). This article looks at how extraordinary images of structures in the body can be created and how inaccessible parts of the body can be examined using various parts of the electromagnetic spectrum.

Thermography

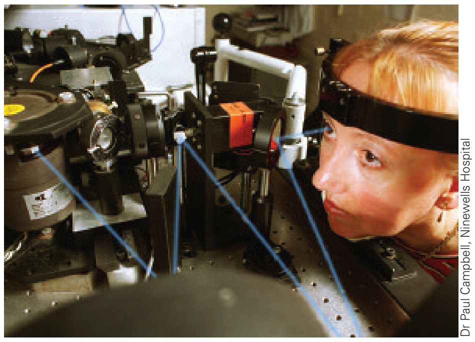
Blood comes from the core of the body and is warmer than the skin, so measuring skin temperature lets us determine whether the blood circulation is healthy or not. A thermogram is a picture of the body which shows the skin temperature.

The first thermogram was done by Hippocrates in Ancient Greece in about 400 BC, although he did not use a camera! He covered the body with clay and watched where it dried out first. The place where it dried out first was the warmest part of the body and might show an infection or other inflammation. Nowadays, we use a camera that is sensitive to infrared light.

Radiations in the electromagnetic spectrum all travel at the speed of light in space – 300 million m/s.



***Right:** Thermogram of poor circulation in a human foot (left) compared to a normal foot (right). The temperature range goes from hot (white) to cold (blue)*



A scanning laser ophthalmoscope

Lights in your eye

Bright light in visible wavelengths allows an ophthalmologist (an eye doctor) to examine a patient's eyes. A scanning laser ophthalmoscope, for example, detects light reflected from the back of the eye and can detect problems with the retina. Blue light gives information about the surface of the retina, while red light can pass through the first layers and tell us about deeper layers. It can help to prevent blindness due to retinal damage in people with diabetes.

Near infrared spectroscopy

Psychologists would like to know how the brain develops from birth to adulthood. Like muscles, the brain needs blood to bring oxygen to parts which are active. Infrared light is absorbed very strongly by blood. If a region of the brain becomes more active, it receives more blood, and so it will absorb near infrared light more strongly.

Taking measurements of infrared light absorption tells us about the location of activity and the speed of activation in the brain. This is a safe way to detect brain activity, which can be used in children and adults. The system can also be used to monitor and check the blood flow in brains of premature babies.

Endoscopy

An endoscope is used to look deep inside the body. Traditional endoscopes were rigid and therefore uncomfortable. A modern endoscope is highly sophisticated and is so flexible it can even be steered around twists in the intestines.

The first flexible endoscopes used total internal reflection to direct visible light down an optical fibre

5.1 Writing a summary

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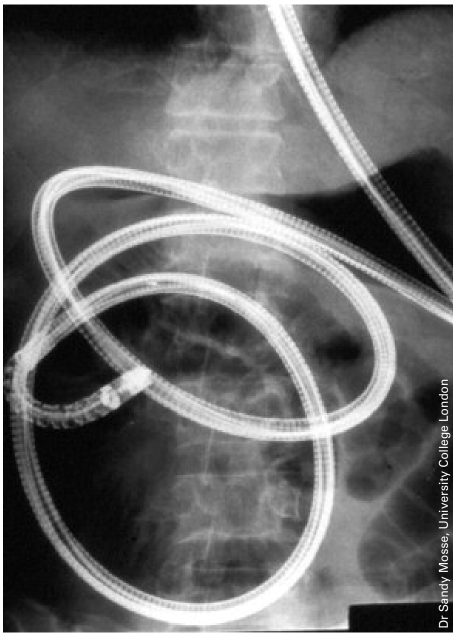


An X-ray image of an endoscope coming down the oesophagus, into the stomach and across into the small and then large intestines

to illuminate the tissue, and then to carry light back up to the fibre to the viewer. Modern endoscopes may use miniature video cameras. They are used not only to make diagnoses, but also to guide instruments inserted through small incisions to carry out keyhole surgery.

X-radiography

Computed tomography (CT) uses X-rays to make a three-dimensional image of the body. It is easier to identify different tissues in a CT image than in a normal X-ray image. Medical physicists make use of the improved contrast in this type of image to extract the shapes of bones and muscles.

Mobile phones

In the September issue of CATALYST we described the working of and issues raised by the use of mobile phones. Medical physicists are involved in examining the possible effects of mobile phones on our brains.

Box 1 Useful websites

Take a look at:
www.crd.ge.com/esl/cgsp/projects/medical
where you will find some Quicktime movies constructed from CT scans.

See images from University College London at:
www.medphys.ucl.ac.uk/mgi

***Left:** Coloured three-dimensional MRI scan of a human foetus in the uterus*

The shorter the wavelength of the electromagnetic radiation, the more likely it is to cause ionisation as it passes through living tissue. This means that gamma rays and X-rays are the most hazardous to living organisms.

Mobile phones use electromagnetic radiation with a wavelength of between 30 cm and about 1 m, close to microwaves. Microwave ovens use higher energy radiation, with a wavelength of about 10 cm. If 10 cm waves can cook food, might wavelengths not that much longer heat you when you use your phone?

Medical physicists use computer programs to calculate the effect of mobile phones on our brains. Although their images show that any heating which may occur is not enough to worry about, mobile phone radiation may affect the brain in other ways. Therefore, following advice from medical physicists performing calculations like these, the government advises young people to make mobile phone calls only when necessary.

Mobile phones now have a published SAR (specific absorption rate) value, which shows energy absorbed during a phone call.

Magnetic resonance imaging (MRI)

The production of MRI images depends on a natural property of matter, called nuclear magnetic resonance. In strong external magnetic fields the atomic nuclei of some elements align themselves in the field, rather like bar magnets. If a radio wave of a particular frequency is applied, the nuclei may realign themselves in the field. The energy absorbed from the radio wave promotes the nucleus to a higher energy level. When the radio wave is switched off the nucleus reverts to a lower energy state. As it does this it emits radio waves at characteristic frequencies. The way this occurs is characteristic of the chemical and physical environment of the nucleus.

- **Tomography** comes from a Greek word meaning 'to cut or slice'. It is linked to the word 'atom'. Find out how.

__Dr Adam Gibson__ is a research fellow in the Department of Medical Physics and Bioengineering at University College London.

5.1 Writing a summary

Applied Science resource 3

Radioactivity in medicine

Emily Cook

BSIP, Raguet/SPL

***Left:** Doctors examining the results of a patient's PET scan*

GCSE key words
Isotope
Half-life
Meiosis
Mitosis
Mutation

Radiation has many uses in medicine, both in finding out what is wrong with a patient (diagnosis) and in the treatment of cancer (therapy). In the last issue of CATALYST, we looked at the medical uses of electromagnetic radiation. In this issue, we focus on the uses of radiation from radioactive materials.

Radioactivity has been used in medicine since soon after it was discovered in 1896. For a while it became the latest health fad: people drank water with radium in it, put it in their baths and even made toothpaste out of it. Many people claimed that radiation cured all kinds of diseases, and an article in the reputable publication the *American Journal of Clinical Medicine* stated that: 'Radioactivity prevents insanity, rouses noble emotions, retards old age, and creates a splendid youthful joyous life.'

However, it soon became apparent that the people who used these products regularly or worked with radiation, such as the girls who painted radium on the faces of watches to make them glow, were suffering from a number of symptoms. These included burns, hair loss, bone diseases and various types of cancer.

Although the manufacturers of these products made false claims about their benefits, and radiation in large doses can be dangerous, radiation has many uses in modern medicine.

What radiation does to cells

There are three types of ionising radiation: alpha (α), beta (β) and gamma (γ). When a cell absorbs radiation, it may damage the DNA inside the nucleus:

- Sometimes the cell can repair itself with no lasting damage.
- Sometimes the cell repairs itself but with a change in its DNA code (a **mutation**).
- Sometimes the cell is unable to repair itself and dies.

Not all mutations are harmful, though some can kill the cell or cause it to become cancerous and start dividing more rapidly. Cells that are dividing (by **mitosis** or **meiosis**) are more susceptible to radiation damage, so are more likely to be killed.

Fifty years ago, one of CATALYST's editors had a verucca dealt with by having a tiny pellet of radium plastered onto the sole of his foot. He lived to tell the tale!

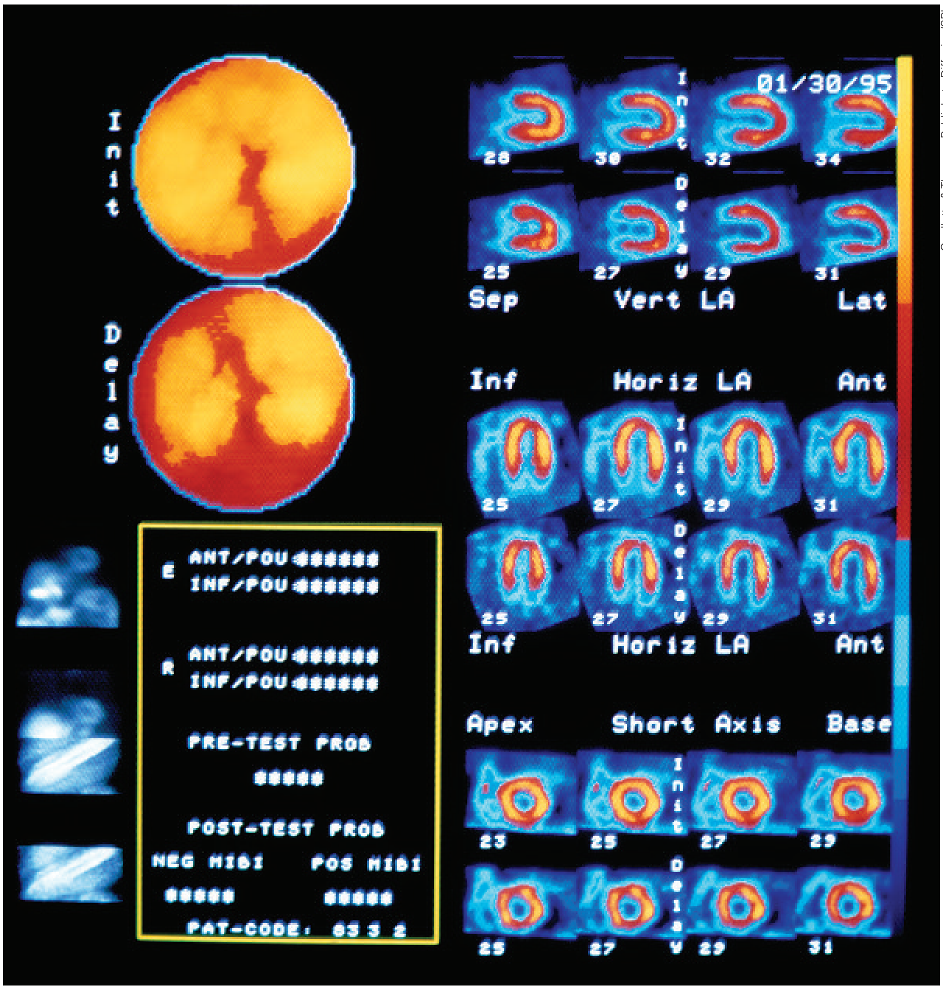
Beta particles are usually negative (–), but they can be positive (+).

- **Which gives greater cause for concern — radiation causing mutation as mitosis is occurring or as meiosis is occurring? (Clue: Think of the type of cells produced by meiosis. Answer is on page 13.)**

5.1 Writing a summary

Applied Science resource 3

Right: *Coloured SPECT scans of blood flow through a human heart*



Ouellette & Theroux, Publiphoto Diffusion/SPL

- **To see more images, search for 'nuclear medicine' in Google Images (www.google.co.uk/imghp).**

Most gamma-emitting isotopes also emit either alpha or beta radiation. Technetium-99 is useful in nuclear medicine because it emits only gamma radiation.

Beta+ particles are also known as positrons or positively-charged electrons; they are particles of antimatter.

When any particle of matter meets its antiparticle, they annihilate, leaving only energy in the form of gamma rays.

Nuclear medicine

Nuclear medicine uses radioactive **isotopes** (radioisotopes) to find out what is going on *inside* the body. X-ray images show the structure of the body, so can only be used to diagnose things like broken bones and some tumours. Unlike X-ray images, nuclear medicine follows what happens to certain chemicals as they pass through the body and so can see if an organ is doing its job properly. The chemicals, called tracers, are labelled with a radioactive isotope and their path through the body can be followed by detecting the radiation they emit.

The radioisotopes are produced in generators in which isotopes with long half-lives (e.g. molybdenum-99, half-life 67 hours) decay to isotopes with shorter lives (e.g. technetium-99m, half-life 6 hours). The shorter half-lives are necessary so the patient does not stay radioactive for much longer than the time it takes to get the images. In fact everyone is slightly radioactive as we have isotopes in our bodies that were taken in as part of food or drink.

The isotope with the shorter half-life is drawn out of the generator in a solution and can be made into a range of drugs (radiopharmaceuticals) that are absorbed by different parts of the body. The radiopharmaceutical is drawn up into a syringe shielded with lead and its dose checked before it is injected into the patient.

The gamma rays given off by the radioisotope are detected by a gamma-camera (a detector that is sensitive to gamma rays). This is connected to a computer and gives an image of the distribution of the isotope in the patient. The image shows where the drug is absorbed, and if several pictures are taken over a period of time it can also show how quickly the isotope is absorbed.

Boxes 1 and 2 describe how two different types of gamma-cameras work.

5.1 Writing a summary

Applied Science resource 3

Box 1 SPECT

SPECT (single photon emission computed tomography) uses a gamma-camera on a ring, which moves around the patient in a circle, taking pictures from many different positions. These pictures go to a computer which produces an image that is a 'slice' through the patient.

The images can either be viewed as a series of slices, or can be made into a three-dimensional image. The process of getting slices is called **tomography** and can also be done using X-rays. This is called CT (computed tomography).

The doctor can see even more information if the X-ray image and SPECT image are combined.

Box 2 PET

PET (positron emission tomography) scanning uses isotopes emitting beta radiation. A beta+ particle travels only about 1 mm before losing its energy and slowing down. When it slows down enough, it will meet a negative electron from a nearby atom and they will annihilate, leaving no particles. Their energy is converted into two gamma rays which travel in opposite directions so that momentum is conserved.

A PET scanner has a ring of detectors so that both gamma rays are seen, and is connected to a computer which can work out where the gamma rays came from and produce an image.

Not all hospitals have PET scanners as they need machines called cyclotrons nearby to produce the beta+ emitting isotopes. The isotopes have a shorter half-life than the gamma emitters used in traditional nuclear medicine (e.g. carbon-11, half-life 20.5 minutes).

Elekta

Above: *A patient being treated in a linear accelerator*


University College London

A combined PET/CT scan

Radiotherapy

Radiation is not just used for diagnosis, but can be used for treating cancer. This is called **radiotherapy**. Radiotherapy uses the fact that ionising radiation damages cells, and high enough doses can kill them. The cells in cancerous tissue are dividing rapidly. This makes them more susceptible to damage by radiation than healthy cells, so there is a higher chance that they will be killed and the healthy cells will recover.

Even so, care must be taken to ensure that only the malignant cancer cells, and not the surrounding healthy tissue, receive a high dose of radiation. This is done by mounting the system on a ring so that it can rotate around the patient, with the tumour at the centre of the rotation. In this way the tumour gets a higher dose of radiation than the surrounding healthy tissue.

Some radiotherapy machines use the radioactive element cobalt-60, which emits gamma rays and has a half-life of 5.2 years. It does not need a short half-life as it is not inside the patient, and the machine keeps the cobalt-60 in a 'head' with lead shielding around it that the gamma rays cannot pass through. More recent radiotherapy machines have linear accelerators instead of a radioactive source. Linear accelerators (linacs) produce high energy X-ray beams, which are electromagnetic like gamma rays.

Conclusion

Although radiation needs to be handled with care, it can be used in many different ways to diagnose and treat illnesses, and new ways to use radiation to care for people are still being found.

__Emily Cook__ was a science teacher. She now works in the Department of Medical Physics and Bioengineering at University College London.

- **Patients who have undergone diagnosis or treatment in which a radioactive substance has been introduced into their bodies may be warned to flush the toilet several times after use, and to avoid kissing anyone. Can you think why?**

By developing more *sensitive* detectors of radiation, the dose of radioactivity given to a patient can be reduced. This means there is less risk to the patient's health — the balance of *benefit* to *risk* is improved.

Meiosis. Sex cells would be affected, so the mutation might be passed on to all cells in any child developing if the sex cell is involved in fertilisation.