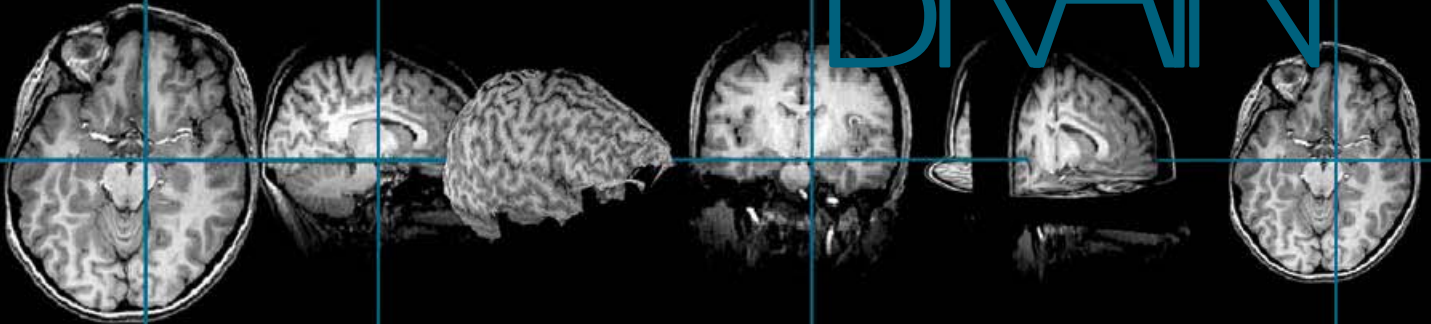


MRC research for lifelong health

# THE BRAIN



MRC

Medical  
Research  
Council

The Medical Research Council (MRC) is dedicated to improving human health through funding the best scientific research. Its work, on behalf of the UK taxpayer, ranges from molecular level science to public health medicine and has led to pioneering discoveries in our understanding of the human body and the diseases which affect us all. This booklet focuses on the brain – explaining what the brain is and what we do and don't know about how it works. It describes some examples of MRC-supported research into the brain and explains how discoveries made by these scientists are being used to develop new treatments and health benefits.

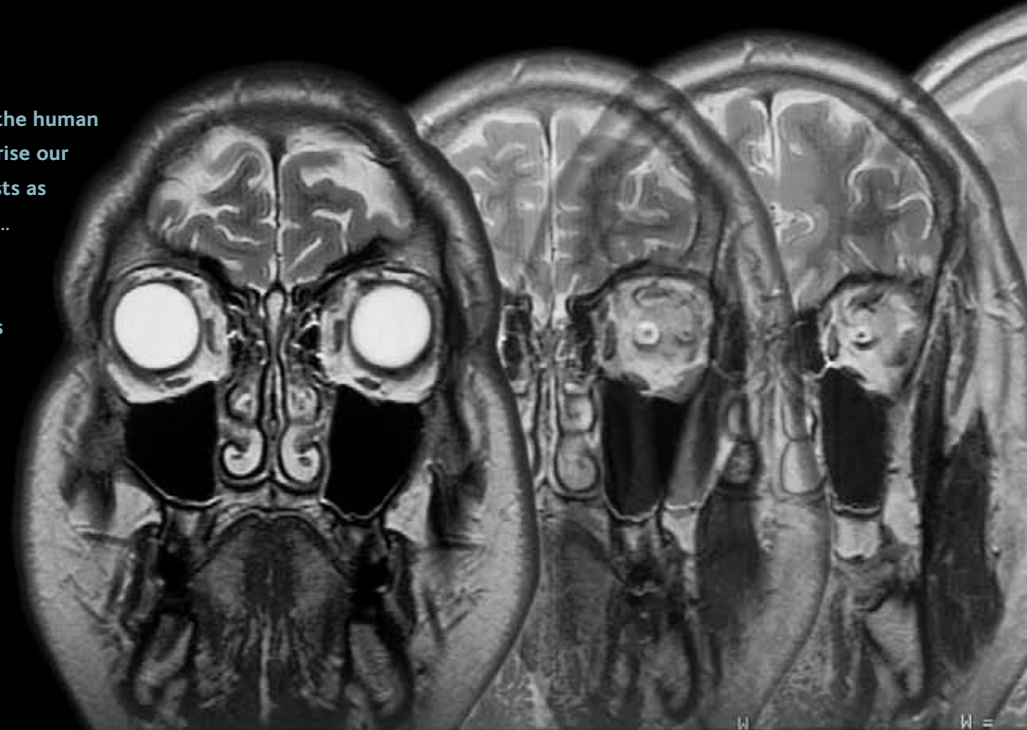


“Men ought to know that from the human brain and from the brain only arise our pleasures, joys, laughter, and jests as

well as our sorrows, pains, grief and tears...

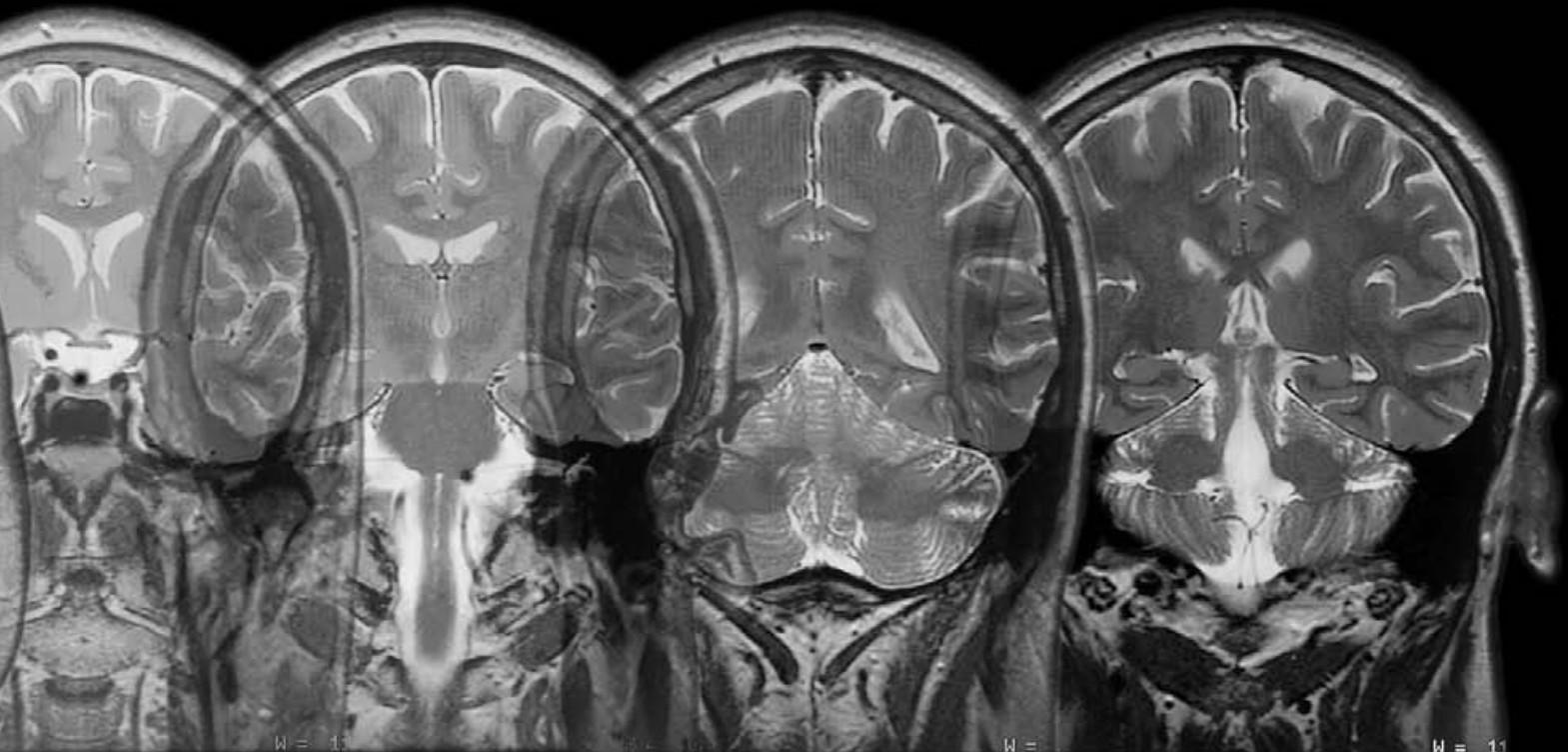
It is the same thing which makes us mad or delirious, inspires us with dread and fear, whether by night or by day, brings us sleeplessness, inopportune mistakes, aimless anxieties, absent mindedness and acts that are contrary to habit.”

HIPPOCRATES, c460-370 BC



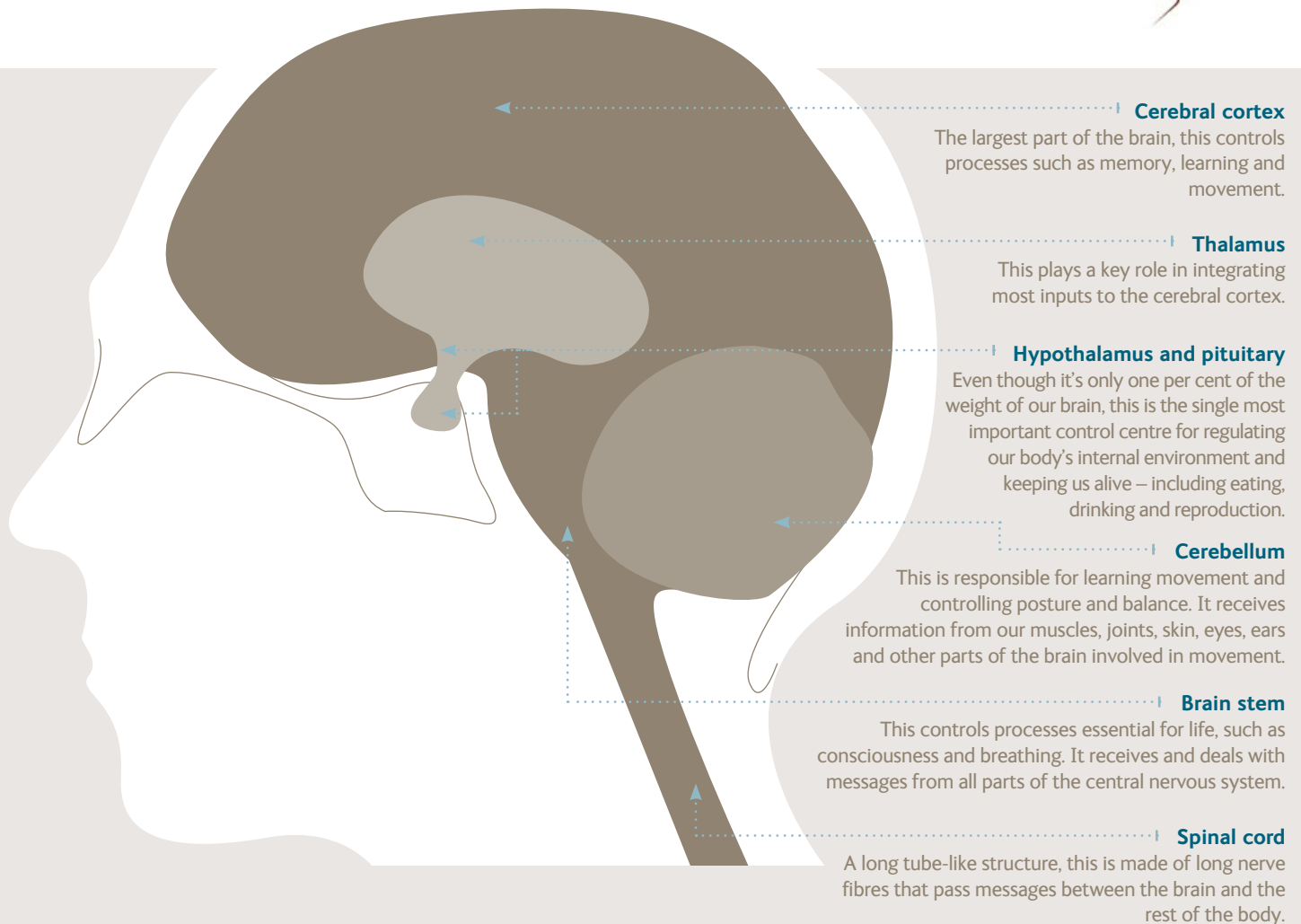
# MRC research: the brain

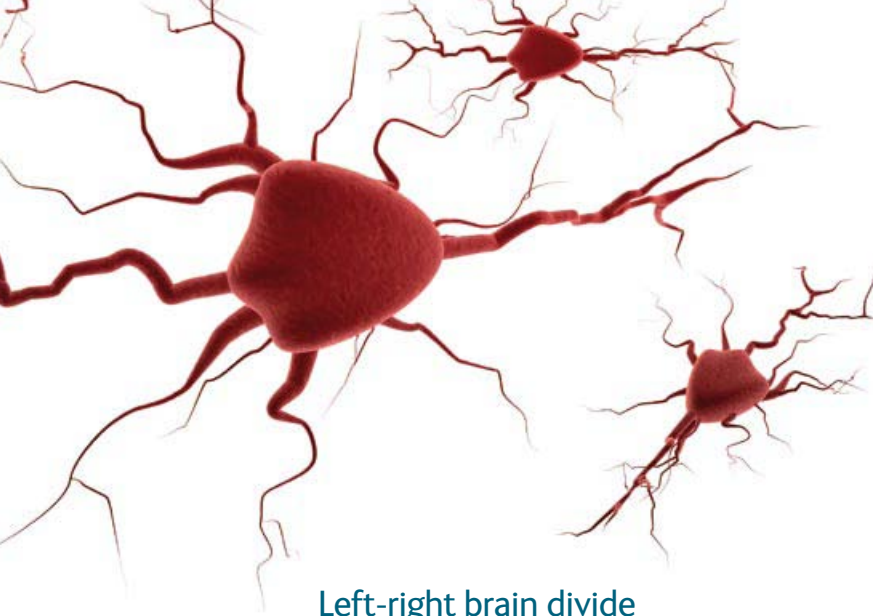
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# About the brain

The brain is the most complex and least understood organ in the human body. It controls all of the body's activities, from breathing and listening to thinking and moving. The main parts of brain are the **brain stem**, the **cerebellum** and the **cerebral cortex**. Each of these has a specific function and controls different activities. The diagram below summarises the parts of the brain and explains what each is responsible for.





## The nervous system

Together, the brain and spinal cord make up the **central nervous system**. The spinal cord is a thin cylinder of soft tissue consisting of nerves that carry messages to and from the brain. It is encased in the bone that runs down the middle of the backbone, just as the brain is encased in the skull.

The brain and spinal cord are connected to the **peripheral nervous system**, which carries information to and from the rest of the body, such as our arms and legs and organs. It is made up of single cells called neurons stretched out into nerve fibres (see page 5). Some of these are very long, for instance, our **sciatic nerves** run the entire length of our legs.

## Left-right brain divide

The cerebrum consists of distinct left and right **hemispheres**. In general, the left part of your brain controls the right side of your body and the right part controls the left side. There is some evidence for each side managing different tasks – for instance, language is mainly processed in the left side of the brain in most people. And whether you are left- or right-handed seems to be down to a division of labour between the hemispheres of your brain. Speaking and tasks involving your hands both require fine motor skills. So it makes sense that one hemisphere of the brain does both – and this is the left hemisphere in most people.

Some people take this theory even further, believing that people tend to be either more ‘left-brained’ (better at maths and language and more rational and analytical) or ‘right-brained’ (more creative, emotional and more likely to take risks). But these are vast generalisations – the only way a person could be completely left- or right-brained is if they had the other half of their brain removed!

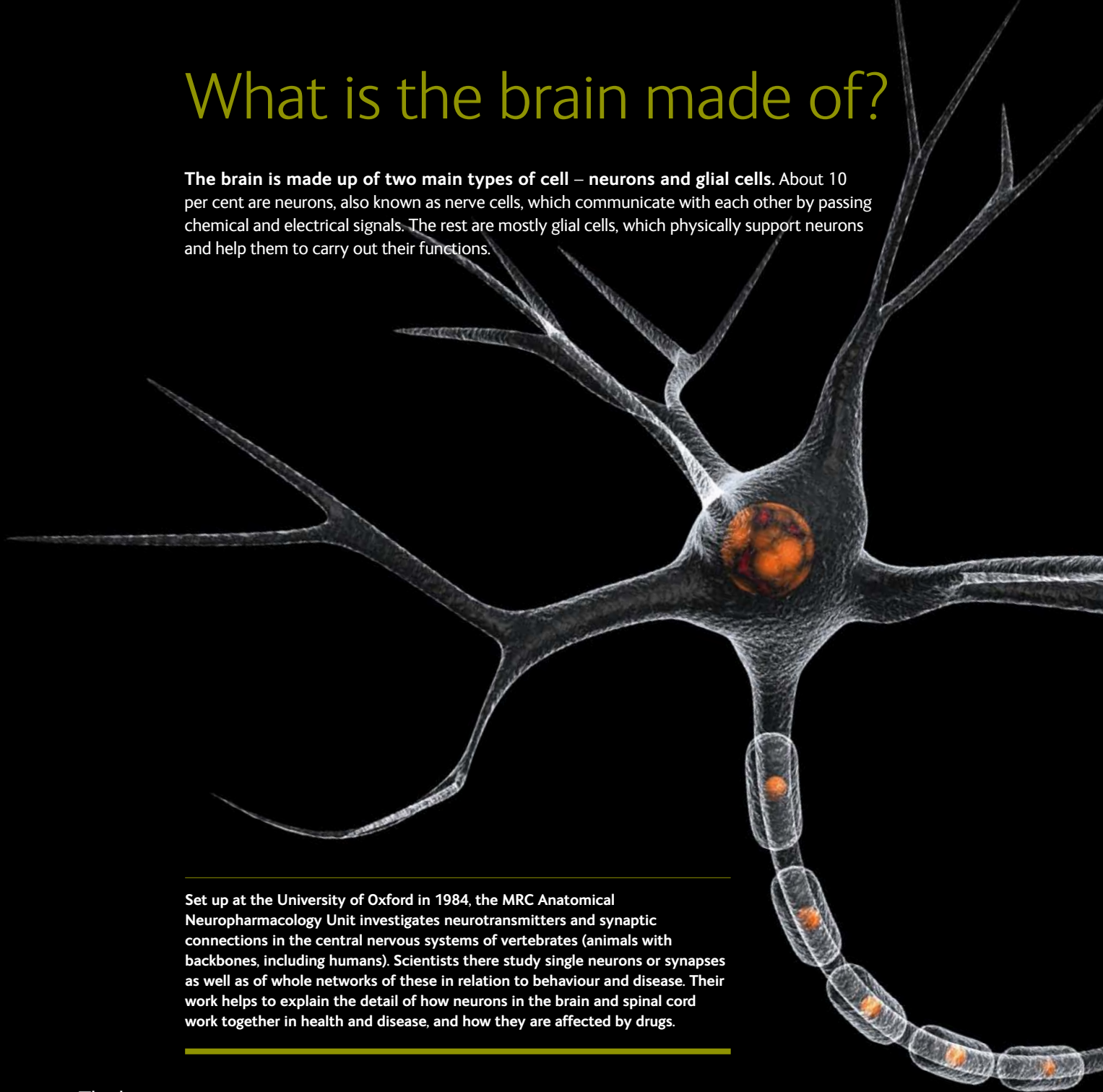
The two hemispheres are connected by a massive bundle of nerve fibres known as the **corpus callosum**. In most people both sides work together to perform almost all mental tasks. Furthermore, people with damage to one side of their brain, for instance due to head injury or stroke, often regain lost abilities as the other side takes over the damaged side’s functions.

### DID YOU KNOW?

- » The human brain weighs around three pounds – 1.3 to 1.4 kg. This is only about two per cent of our body weight – but the brain uses 20 per cent of the body’s oxygen.
- » Our brains are made up of more than 100 billion neurons, each of which is connected to around 10,000 others.
- » About 750 ml of blood is pumped through the brain every minute.
- » The brain itself cannot feel pain – in fact brain surgery is sometimes carried out while patients are awake.
- » The right side of the brain controls the left side of the body and *vice versa*. This is why stroke damage to the right part of the brain, for example, may cause movement or hearing problems in the left side of the body.

# What is the brain made of?

**The brain is made up of two main types of cell – neurons and glial cells.** About 10 per cent are neurons, also known as nerve cells, which communicate with each other by passing chemical and electrical signals. The rest are mostly glial cells, which physically support neurons and help them to carry out their functions.



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Set up at the University of Oxford in 1984, the MRC Anatomical Neuropharmacology Unit investigates neurotransmitters and synaptic connections in the central nervous systems of vertebrates (animals with backbones, including humans). Scientists there study single neurons or synapses as well as of whole networks of these in relation to behaviour and disease. Their work helps to explain the detail of how neurons in the brain and spinal cord work together in health and disease, and how they are affected by drugs.

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## Neurons

Neurons are the basic units of the central nervous system. Each neuron has:

- » A **cell body**, which contains the cell's genetic information.
- » **Dendrites**, which receive information from other neurons.
- » An **axon** (also called a nerve fibre). Many of these are coated in a **myelin sheath** – a protein and fat layer that speeds the movement of electrical impulses down the neuron.

The terms **grey matter** and **white matter** refer to the make-up of different areas of the brain: grey matter consists mostly of the cell bodies of neurons, and white matter is made up of the axons that connect them.

The space between two adjacent neurons is known as a **synapse**. Neurons communicate with each other by passing electrical or chemical impulses from one to another through these synapses. The chemicals that stimulate adjacent neurons are known as **neurotransmitters**. They include: acetylcholine, which regulates voluntary muscle movement; serotonin, which affects memory, emotions, wakefulness, sleep and temperature regulation; noradrenalin, which is responsible for wakefulness and arousal; and dopamine, which has many functions in the brain including in behaviour and cognition, motivation and reward, control of movement, sleep, attention and learning.

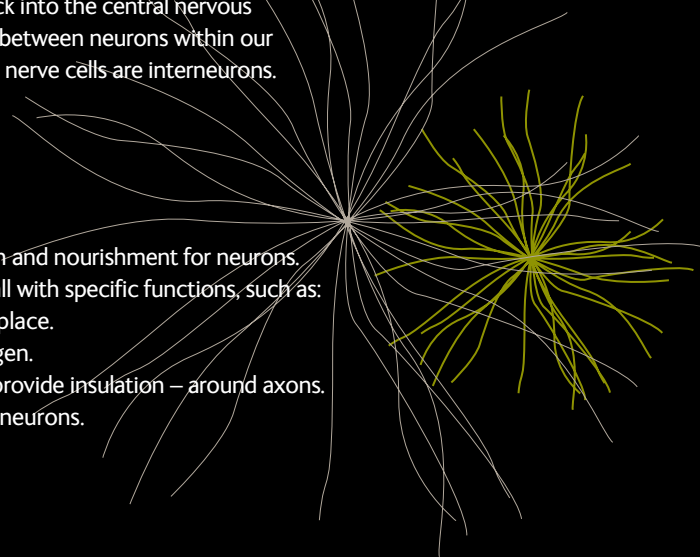
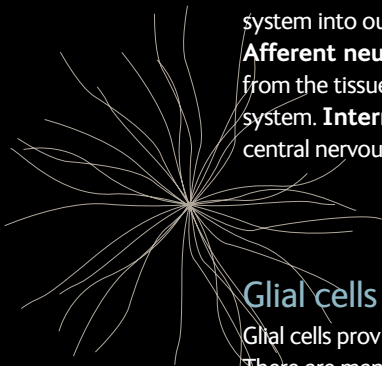
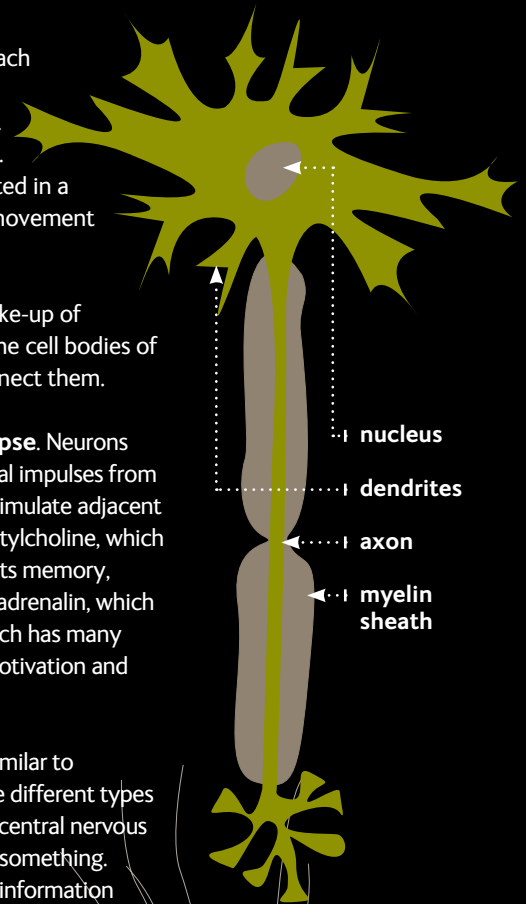
Interconnected neurons form **neural networks**. These are similar to electrical circuits but much more complicated. There are three different types of neurons. **Efferent neurons** convey information from the central nervous system into our bodies, for example, to tell our muscles to do something. **Afferent neurons** work the other way around, and transmit information from the tissues and organs of our bodies back into the central nervous system. **Interneurons** provide connections between neurons within our central nervous system. About 99 per cent of nerve cells are interneurons.

## Glial cells

Glial cells provide physical support, protection and nourishment for neurons.

There are many different types of glial cells, all with specific functions, such as:

- » Surrounding neurons and holding them in place.
- » Supplying neurons with nutrients and oxygen.
- » Creating myelin sheaths – fatty layers that provide insulation – around axons.
- » Destroying pathogens and removing dead neurons.



## The developing brain

The human brain starts to develop at a very early stage – the first signs of the developing nervous system can be seen in an embryo after about 16 days of growth. Brain development happens very quickly. At some stages of growth up to 250,000 neurons are formed every minute. By the time a baby is born, almost all the 100 billion neurons it will ever have are already there. But the brain continues to grow and develop for many years after birth, as links between neurons are formed and the number of glial cells that provide support for these neurons (see page 5) increases rapidly.

As a baby grows and learns and its brain develops, connections are made and strengthened between different neurons. There are times in the development of the brain that are thought to be better for learning different things. For instance, learning a language seems to be easiest before the age of 10. Our brain reaches its adult weight by the time we are teenagers, but it continues to go on forming new connections as we keep learning new things throughout our lives. In the same way, the brain removes connections between neurons that aren't used.

This ability of the brain to change and adapt is known as **plasticity**. It is this characteristic that allows people to re-learn things like walking and talking, even if the parts of their brain responsible are damaged beyond repair. Another part of the brain can step in and learn how to control the activities that used to be managed by the damaged part of the brain.

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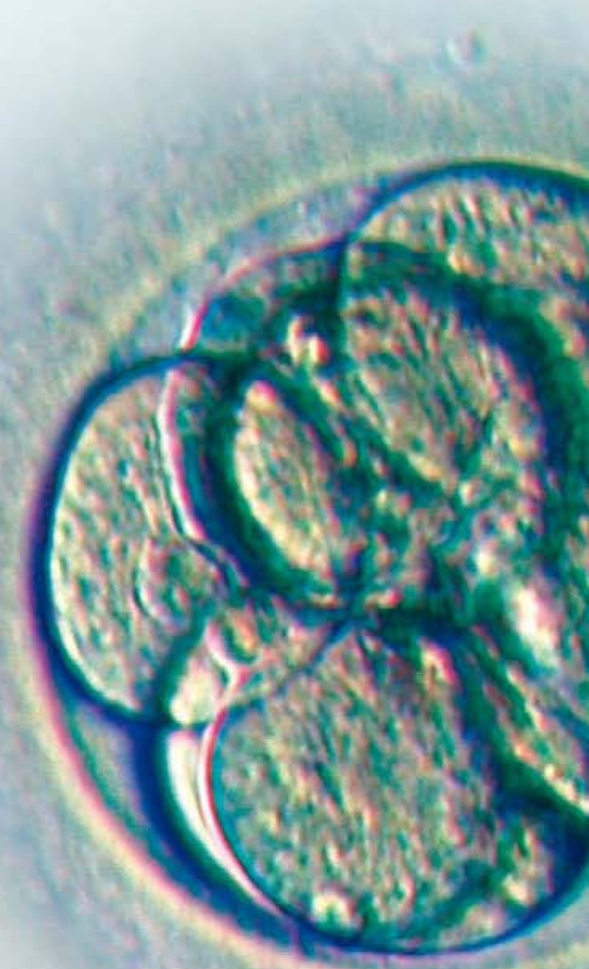
The MRC Centre for Developmental Neurobiology at King's College London is working to understand the early events that occur during **brain development**. Increased knowledge of how the brain develops should help in understanding the mechanisms that lead to problems in the formation of the brain and that stop the human nervous system from being able to repair itself. Scientists at the Centre use different animals, such as mice, zebra fish and fruit flies, as models for studying human brain development.

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This **plasticity of the brain** is the focus of research at the MRC Centre for Synaptic Plasticity at the University of Bristol. Specifically, the Centre's researchers are trying to increase understanding of how, where and why the brain changes the strength of synapses during normal function, particularly during tasks involving learning and memory. They also investigate synaptic plasticity in certain diseases, such as in Alzheimer's disease. The Centre works closely with other neuroscientists in universities and industry to try to find ways to turn their molecular discoveries into targets for new drugs.

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## Protecting the brain

The **skull** that protects the brain is made up of 29 separate bones. Most of these bones, except for the lower jaw bone, are held together by rigid structures that don't allow them to move very much. Inside the skull, the brain is surrounded by three tough membranes called **meninges**. The innermost layer, called the **pia**, is a delicate membrane made from a thin fibrous tissue. It follows the contours of the brain and spinal cord precisely and has capillaries that provide nutrients and oxygen to the brain.

The middle layer, called the **arachnoid**, is named because of its spider web-like appearance. There is a space between the pia and arachnoid layers called the **subarachnoid space**, which is filled with a liquid called cerebrospinal fluid. The **cerebrospinal fluid** fills all the gaps around the brain and protects and cushions it.

The **dura** is the outermost membrane, closest to the skull. It is a thick and durable membrane and contains large blood vessels that split into the capillaries in the pia. It is tough and inflexible and surrounds and supports two large veins that carry blood from the brain back to the heart.

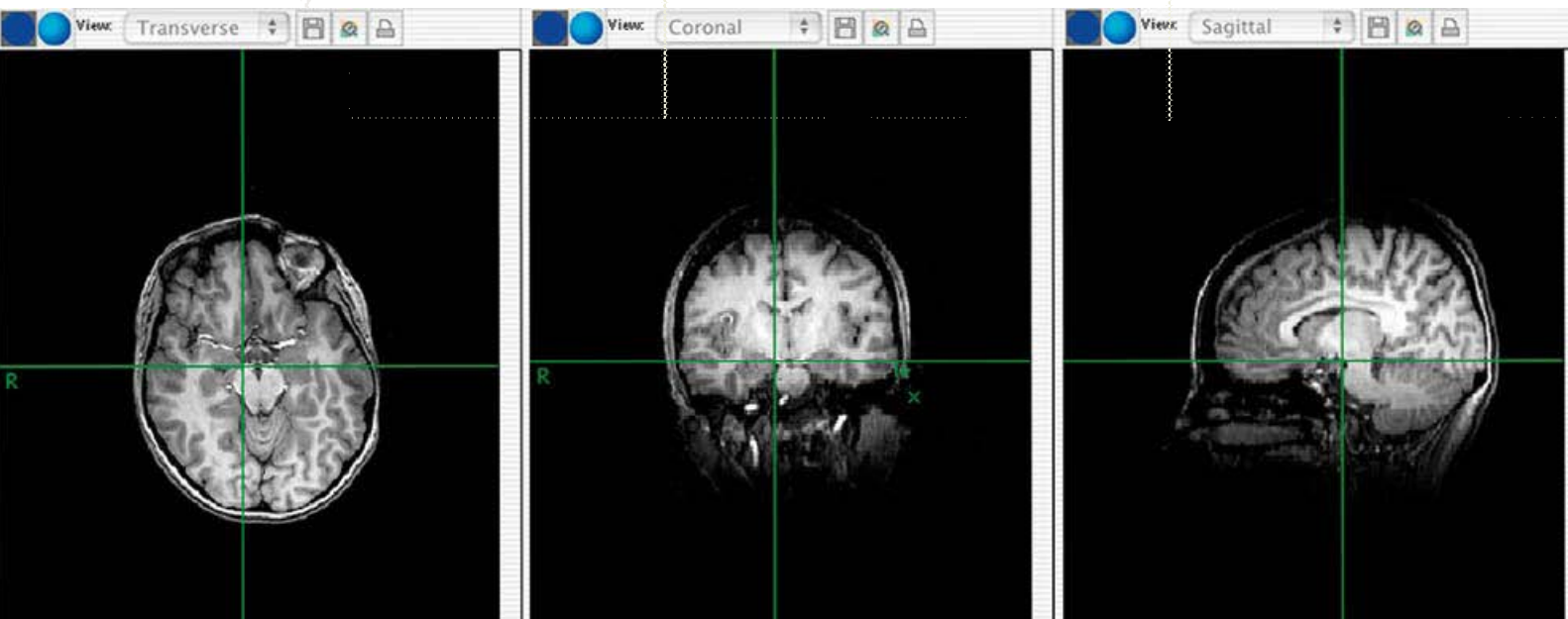


**Multiple Sclerosis (MS)** is the most common disabling neurological disorder affecting young adults in the UK. It is caused by the body's own immune system attacking and damaging the myelin that surrounds and protects neurons. This interferes with messages between the brain and other parts of the body. It can affect many functions, from bladder and bowel control, to movement, mood and memory. MS can also cause pain, fatigue, tremor and problems with swallowing, speaking and seeing. For some people it is characterised by periods of relapse and remission, while in others it gets progressively worse. Current treatments can decrease the number of attacks but have no effect on the progression of the disease. MRC-funded scientist Professor Richard Reynolds, who heads an MS tissue bank at Imperial College London, showed that around four out of 10 people who die with progressive MS had extensive damage to the surface of their brains, with inflammation in the tissue lining it (the meninges, see above). These people tended to have more aggressive MS than other sufferers and die earlier. Now, Professor Reynolds is investigating the differences between what happens in the brains of this group of patients and those without this type of inflammation. He is using 'gene chips' – small chips that can be used to study all of the human genes at once – to try to find out which genes are involved in the more severe form of the disease. "We hope that this work will lead to ways to identify this group of patients with a higher risk of a poor outcome, enabling earlier treatment before extensive and irreversible damage has already happened," said Professor Reynolds.

# Taking pictures of the brain

**Scientists have been intrigued by the brain for thousands of years.** As far back as the fifth century BC, the Greek mathematician Hippocrates recognised that the brain was the centre of intelligence and controlled the senses. Researchers are continually making progress in understanding this complex organ and finding new ways to study it. But despite this, the brain remains the least understood organ in our bodies.

Nevertheless, recent advances in imaging techniques mean that the field of neuroscience is now advancing more rapidly than ever before. There are two main ways of looking at the brain – called **structural imaging** and **functional imaging**. Structural imaging allows scientists to view large scale brain injury or disease, such as tumours. Functional imaging is used to study the brain in action. It can be used to diagnose problems on a smaller scale. It enables scientists to pinpoint the areas of the brain that are responsible for different processes and behaviour.



## MRI scanning

Until 30 years ago, doctors had to rely on X-rays for showing bones and dense clumps of cells like tumours inside our bodies. Then scientists started using magnetic resonance imaging (MRI) – which makes use of the magnetic properties of molecules in cells – to create images of the body.

The field took a huge leap forward in 1973 when MRC-funded scientist Sir Peter Mansfield used MRI to produce exquisitely detailed images of soft tissues. He won the 2003 Nobel Prize in Physiology or Medicine for this work. The technique enabled doctors for the first time to peer deep inside the body to diagnose disease without exposing patients to the trauma of exploratory surgery. Advances in high speed computing and superconducting magnets have since allowed researchers to build ever more powerful MRI scanners.

Today these are capable of producing stunningly clear images, making it possible to detect very early tumours and subtle damage to tissues including delicate nerve fibres.

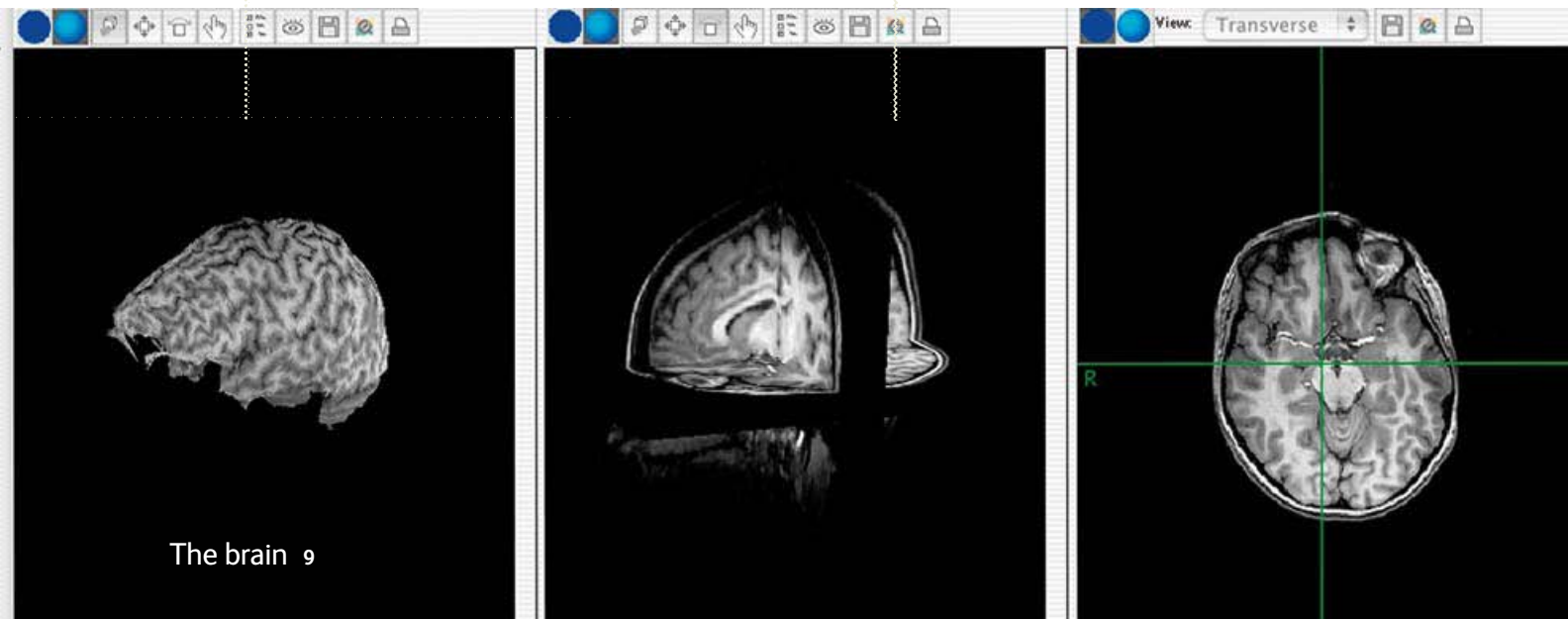
## Functional MRI

MRI's offspring, functional MRI (fMRI), is helping scientists to gain the first real understanding of how the brain works by enabling them to view the working brain. When a part of the brain is active, blood flow to it increases because extra nutrients and oxygen are needed. fMRI scanners can show areas where there is more blood flow, hence showing active areas of the brain. By producing images every few seconds, brain activity can be visualised as volunteers or patients react to stimuli or are asked to perform tasks using their brain. fMRI is today one of the most widely used ways of visualising brain activity.

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Drs Andy Calder and Andrew Lawrence at the MRC Cognition and Brain Sciences Unit in Cambridge used fMRI in a study showing how some people's brains are particularly vulnerable to food advertising and product packaging, putting them at risk of **overeating** and becoming overweight.

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## CT scanning

MRC research also played a role in the origin of computed tomography (CT) imaging, also known as 'CAT scanning' (computed axial tomography), a way of using X-rays to take images of parts of the body. CT scanning builds up three-dimensional images from large numbers of low-dose X-rays transmitted across the body. In a traditional X-ray film, there is no dimension of depth.

This method stemmed from research by Sir Aaron Klug at the MRC Laboratory of Molecular Biology, who put together 'slices' – layered electron microscopy images – to form a detailed picture with depth. Sir Aaron combined conventional electron microscopy with the use of X-rays to enhance the resolution of images of proteins.

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These days CT scanning is widely used, including by researchers studying the brain. For instance, Dr Andrew Jackson of the MRC Human Genetics Unit in Edinburgh uses CT scanning to visualise calcification and brain damage in patients with the rare genetic condition *Aicardi Goutières Syndrome (AGS)*. AGS is a severe condition affecting the brain and the immune system, causing loss of white matter and inflammation in the brain. Its symptoms usually appear in the first six months of life, generally causing profound intellectual and physical impairment.

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## PET scanning

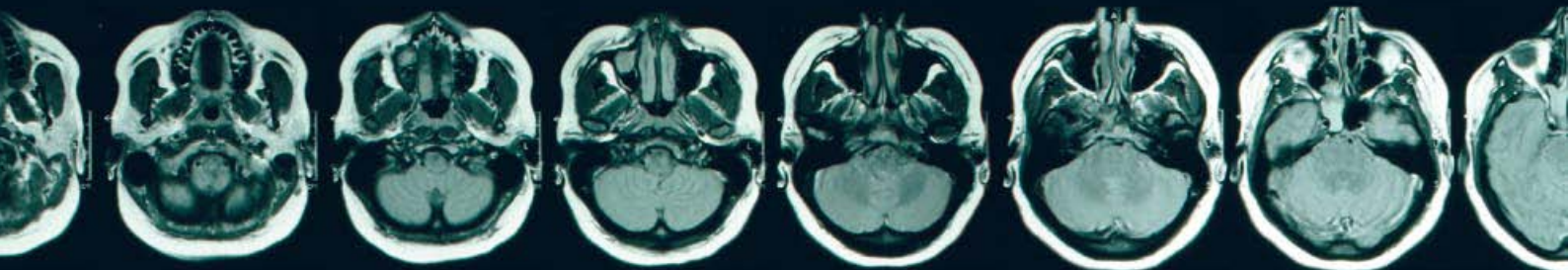
Positron emission tomography, also called PET imaging or a PET scan, is a highly sophisticated scanning technology used to create images of what is happening at a molecular level inside the body. As one of the most important tools in hospital diagnosis, research and drug discovery around the world, it has increased understanding of disease processes and treatment in areas such as movement disorders, stroke, dementia and coronary heart disease.

PET involves the collection of images based on the detection of radiation from the emission of positrons – particles emitted from a short-lived radioactive substance given to a patient by injection or inhalation.

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PET scanning is used extensively by scientists at the MRC Clinical Sciences Centre at Hammersmith Hospital in London. For instance, Dr Alexander Hammers leads an *epilepsy* research group in the brain disorders section. Epilepsy is the most common serious neurological disorder, affecting one in 130 people. It is defined as a tendency to have recurrent seizures, and is caused by bursts of excess electrical activity in the brain. This temporarily disrupts the normal messages that pass between neurons in the brain, resulting in disruption to the functions of the body controlled by the affected brain areas. Dr Hammers' group is using PET and MRI imaging to study changes in brain structure and the way in which electrical messages are passed between neurons people with epilepsy. They want to find out why seizures occur, where in the brain they happen and why they stop. The research will help in the development of new drugs, and can also be used to pinpoint parts of the brain affected for patients who don't respond to drugs and need to be treated surgically.

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## EEG scanning

The brain's electrical activity can be measured by placing electrodes on the scalp through a process known as **electroencephalography** (EEG). Because it can monitor changes that happen in brain activity in milliseconds, it is useful for researchers to study the brain as it is working. EEG is commonly used to study sleep and sleep disorders.

At Imperial College London, Professor Nick Franks is using EEG and molecular genetics to study how and where general anaesthetics act in the brain. These drugs have been used for more than 150 years but exactly how they work is still not understood. There is thought to be a link between sleep and anaesthetics – there is evidence that anaesthetics cause their sedative effects by affecting natural sleep pathways. But currently available drugs are relatively non-specific and can cause nasty side effects. If particular pathways in the brain could be specifically targeted, these side effects would be reduced and anaesthetic treatment would become safer and more pleasant. Professor Franks' work also has implications for understanding natural sleep pathways and may help in the treatment of increasingly common sleeping disorders.

## MEG scanning

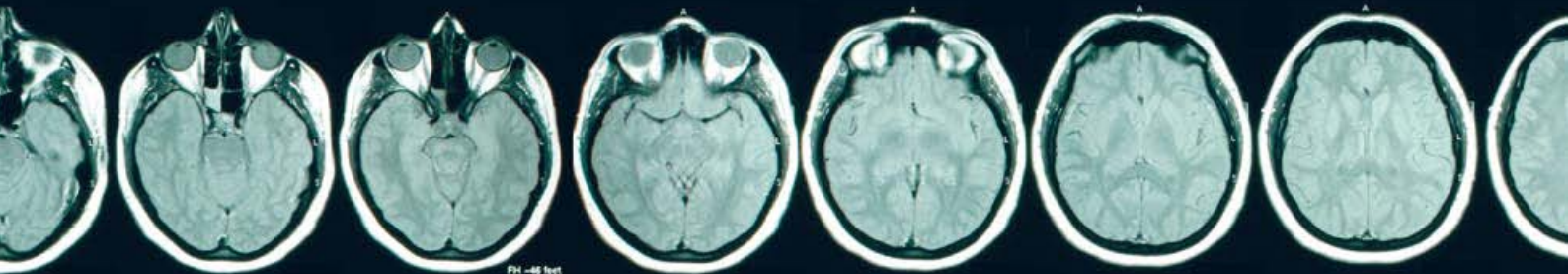
A newer related technique is called **magnetoencephalography** (MEG). MEG is similar to EEG but instead of picking up electrical impulses in the brain it measures the tiny magnetic pulses the brain gives off. An advantage is that it is faster than other scanning techniques and so can chart changes in brain activity as they happen.

Dr Katrin Krumbholz heads the human electrophysiology group at the MRC's Institute of Hearing Research in Nottingham. Her team combines EEG with fMRI to try to find out how sound information is encoded by the brain. She has also recently begun working with a new MEG scanner, which shows what's happening in the brain in real time. "This is important because the auditory system seems to have a special mechanism for localising sounds. It can detect minute time differences in sounds arriving at the ears to help work out where they are coming from," said Dr Krumbholz. "It is very precise – much more so than any other sensory system."

The MRC Cognition and Brain Sciences Unit in Cambridge installed a MEG scanner late in 2006. The scanner is being used by staff across the unit to investigate topics including the brain mechanisms of language, human memory and perception of objects (including people's faces).

### FIND OUT MORE: STORIES OF DISCOVERY

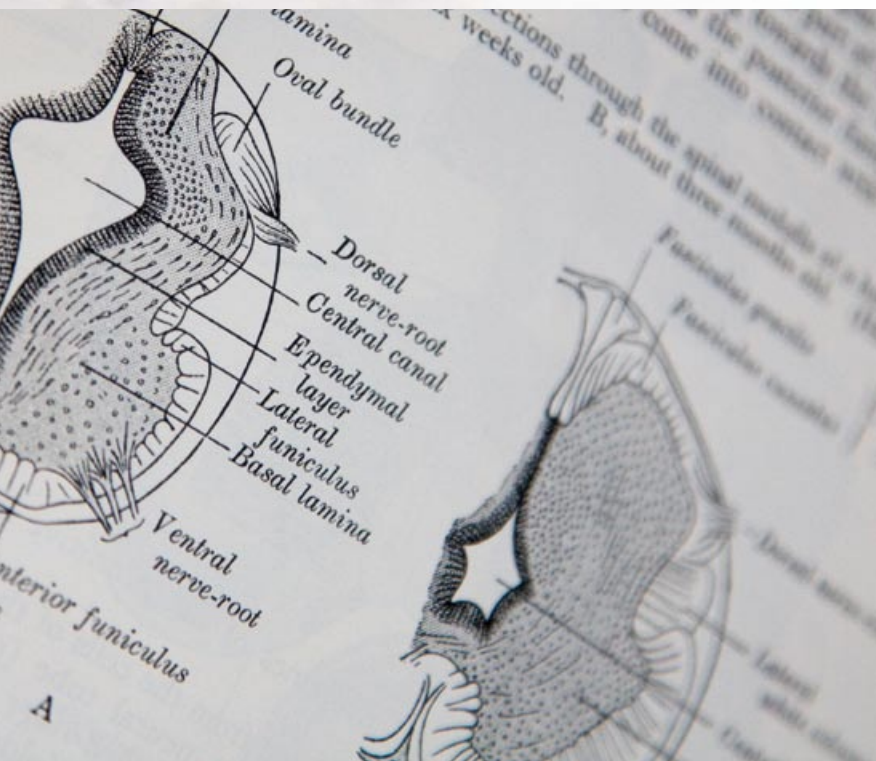
Visit the MRC website to read our 'Stories of discovery', which track the journeys from scientific breakthroughs to health improvements. There are many factors that influence the healthcare we receive – the story usually begins with discoveries by scientists working in laboratories. Once they spot the potential of a piece of work, they begin developing it with clear goals in mind; to help cure and prevent disease. Other advances come about when researchers study the spread of a disease between people, or how best to introduce a new treatment. Building on these discoveries, politicians and doctors are key to changes in public health policies or the application of new treatments. To read about the history of medical imaging and the part the MRC played in its development, visit [www.mrc.ac.uk/Achievementsimpact/brainsenses](http://www.mrc.ac.uk/Achievementsimpact/brainsenses).



# Other ways to study the brain

## Molecular biology

Breakthroughs in neuroscience often go hand in hand with technological advances. As well as using the imaging techniques described above, neuroscientists use a range of other tactics to study the brain. For instance, cell and tissue biology, biochemistry, microscopy, animal studies, psychiatry and neuropathology can all provide insights into what's going on inside a person's brain.



Dr Michel Goedert heads the Neurobiology Division at the MRC Laboratory of Molecular Biology in Cambridge. The Division's goal is to discover how the nervous system performs its various tasks. Dr Goedert and his colleagues use molecular biology techniques to explore the fundamental properties of nerve cells. Their work is helping to improve understanding of the mechanisms that enable nerve cells to rapidly transmit and process information, as well as the chemical pathways responsible for the short- and long-term changes in the brain associated with unique functions such as memory formation. They are also studying the molecular processes that lead to neurodegenerative disorders such as Alzheimer's disease.

Researchers at the MRC Social and Genetic Developmental Psychiatry Centre at the Institute of Psychiatry, King's College London aim to bridge the gap between 'nature' (genetics) and 'nurture' (environment). They are trying to work out how these interact in the development of complex **behaviour traits and disorders** such as **autism**. New collaborative interdisciplinary research is a hallmark of the Centre. This is because the interaction between nature and nurture spans environmental approaches from epidemiology to family environment, and genetic approaches from studies of twins and adopted children to molecular genetics.

For instance, Professor Terri Moffitt is tracking mental diseases from childhood to adulthood in a large long-term study that aims to generate information about four common conditions – **depression, antisocial disorders, schizophrenia, and substance disorders** (such as **drug abuse**) – in the first four decades of life. The study, which has tracked 1,000 men and women based in New Zealand since 1972, is looking at differences in the onset and course of these conditions. The findings might help explain why some people are affected while others are not – it is hoped the work will lead to improved methods of treatment and prevention.

## Social, genetic and psychiatric research

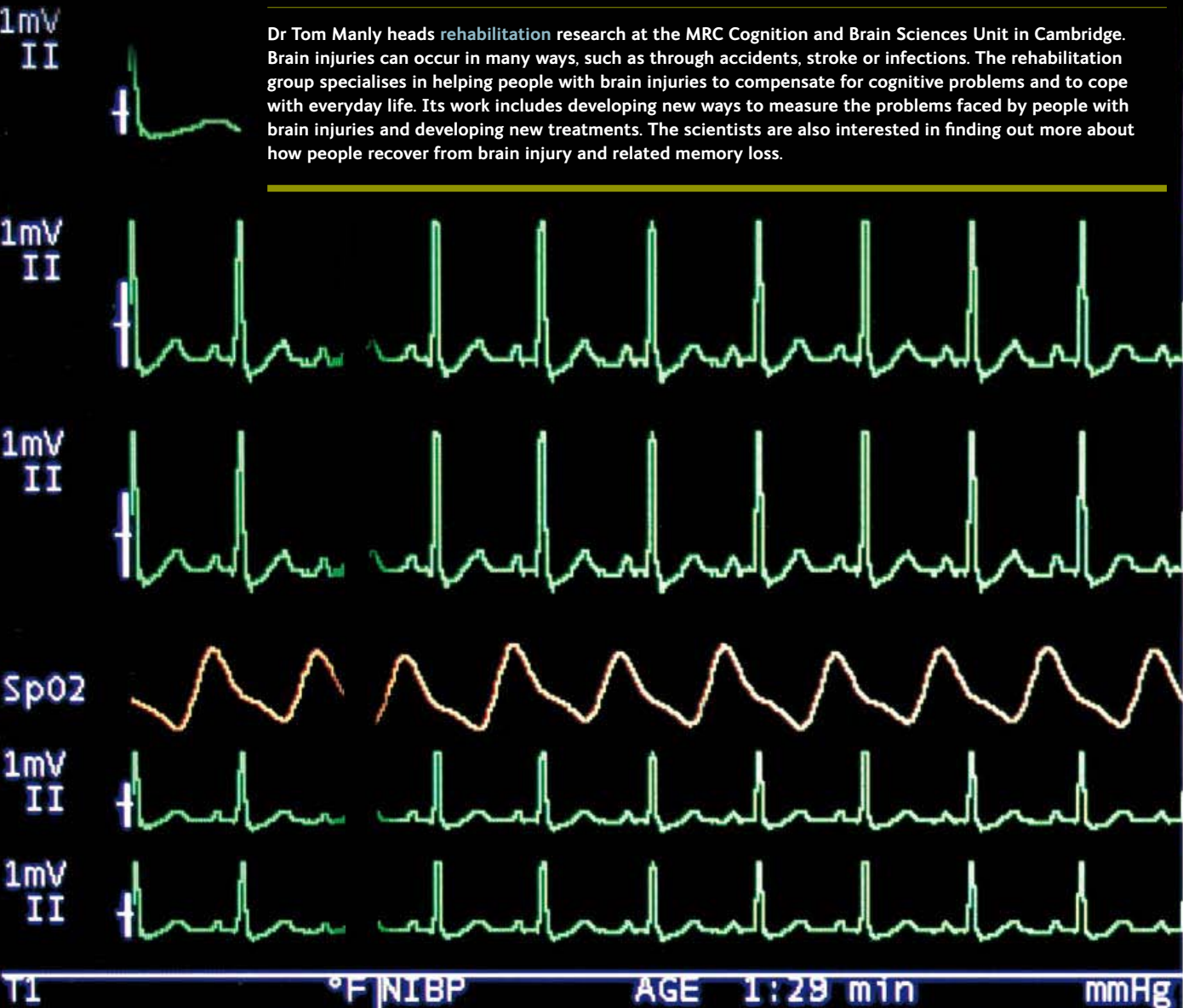
There are many external factors that may all play a role in how our brain is set up and operates. Our environment, our genes, our experiences and social factors have all been implicated.



# What does the brain do?

The brain controls all the body's functions – from consciousness and heart rate to thinking, memory and emotion. It is the most complex thing we know of, and the gaps in our knowledge about how it works are vast. Neuroscientists have the daunting job of making sense of this complicated organ – to provide insights into our minds and behaviour and to find ways to tackle debilitating brain diseases and injuries.

Dr Tom Manly heads rehabilitation research at the MRC Cognition and Brain Sciences Unit in Cambridge. Brain injuries can occur in many ways, such as through accidents, stroke or infections. The rehabilitation group specialises in helping people with brain injuries to compensate for cognitive problems and to cope with everyday life. Its work includes developing new ways to measure the problems faced by people with brain injuries and developing new treatments. The scientists are also interested in finding out more about how people recover from brain injury and related memory loss.



## Core body functions

The brain stem controls what are known as our core body functions – the things our body must do unconsciously to keep us alive, such as altering our heart beat and regulating our blood pressure and body temperature. It also controls functions such as alertness, swallowing, digestion and breathing.

## Consciousness

Consciousness is part of what makes each of us unique. It encompasses many of our ideas, thoughts, feelings, plans and memories. Conscious thought is different from the unconscious workings of the brain – which enable us to breathe, walk and talk and our hearts to beat automatically.

There are two aspects to consciousness: awareness and wakefulness.

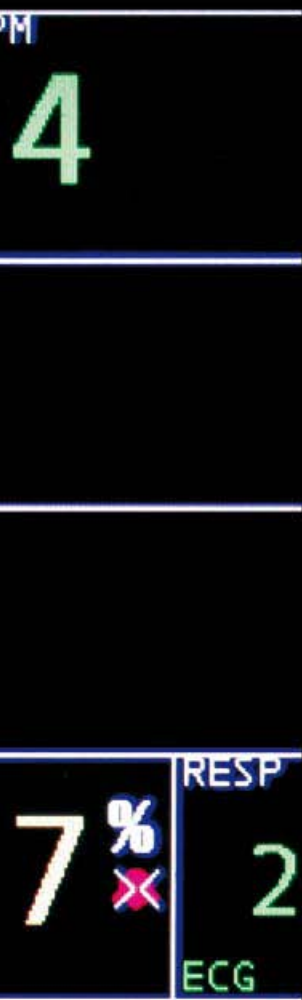
- » **Awareness** refers to our internal, subjective experience. It includes **self awareness** – the ability to understand that you exist, as an individual, separate from other people and with private thoughts. It also includes **awareness of the relationship between oneself and one's environment** through use of our senses and by thinking about ideas and acting upon them using judgement.
- » **Wakefulness** refers to different levels of conscious awareness. Each day we experience a spectrum of wakefulness, from full attentiveness, such as if we are involved in an interesting conversation, through inattentiveness, drowsiness and normal sleep. Following some types of brain injury or during anaesthesia people can't be woken: they have a lower level of wakefulness. Brain death lies at the far end of this spectrum.

These two aspects of consciousness normally go hand-in-hand; we don't expect to have an interesting conversation with someone who is asleep. However, we can possess awareness when we are asleep, for example when we dream.

### Where does consciousness come from?

Scientists have amassed much evidence linking different aspects of consciousness to our brain. We now know that consciousness requires many parts of the brain to work together. Parts of the **cerebral cortex** act together to produce our thoughts and experiences. A functioning **thalamus** is also required to produce wakefulness – we know this because if a part of the thalamus called the **centromedian nucleus** becomes damaged, we become unconscious.

**Unconsciousness** can also be caused by anaesthesia, or changes to the body's internal environment such as a rise or drop in core body temperature or a lack of oxygen. A prolonged period of unconsciousness is known as a **coma**. Sometimes, after a severe brain injury, a person can enter a **vegetative state (VS)**. Unlike coma patients, VS patients show normal wake/sleep cycles, but even when they are awake they show no external sign of awareness. When all electrical activity in the brain stops irreversibly, this is known as **brain death**.



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Dr Adrian Owen and his colleagues study patients with disorders of **consciousness** at the MRC Cognition and Brain Sciences Unit in Cambridge. Their work recently revealed that a woman who was diagnosed as being in a persistent vegetative state following a car accident was aware of her surroundings. Working with colleagues in Belgium, the scientists used functional magnetic resonance imaging (fMRI) to map the woman's brain activity. She was physically unresponsive and fulfilled all the criteria for a diagnosis of vegetative state according to international guidelines. But scans showed that her brain responded to speech. Her brain also actively processed the meaning of sentences, becoming more active when she heard sentences containing words with several meanings, like 'rain' and 'reign'. When asked to imagine playing tennis or moving around her home, brain scans showed that the woman could do this, activating various areas of her brain in the same way as healthy volunteers. "These are startling results. They confirm that, despite the diagnosis of vegetative state, this patient retained the ability to understand spoken commands and to respond to them through her brain activity," said Dr Owen. "Her decision to work with us represents a clear act of intent which confirmed beyond any doubt that she was consciously aware of herself and her surroundings."

Doctors use different levels of **sedation** to reduce people's awareness of their bodies and surroundings. For example, high levels of anaesthetic drugs cause general anaesthesia: a complete loss of consciousness. Another team of scientists at the MRC Cognition and Brain Sciences Unit, led by Dr Matt Davis, used fMRI to study how sedation affects the brain's processing of speech. Working with Professor David Menon and Dr Martin Coleman at the Wolfson Brain Imaging Centre in Cambridge, they found that during heavy sedation, volunteers' brains still responded to the sounds of speech but they were unable to process or remember it. The findings have important implications for the care of patients undergoing general anaesthesia or coming out of a coma.

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## Emotion

Emotions, like happiness, sadness, confusion and anger, tend to occur unconsciously. They often cause physical responses, such as smiling, crying, sweating or increased heart rate or blood pressure.

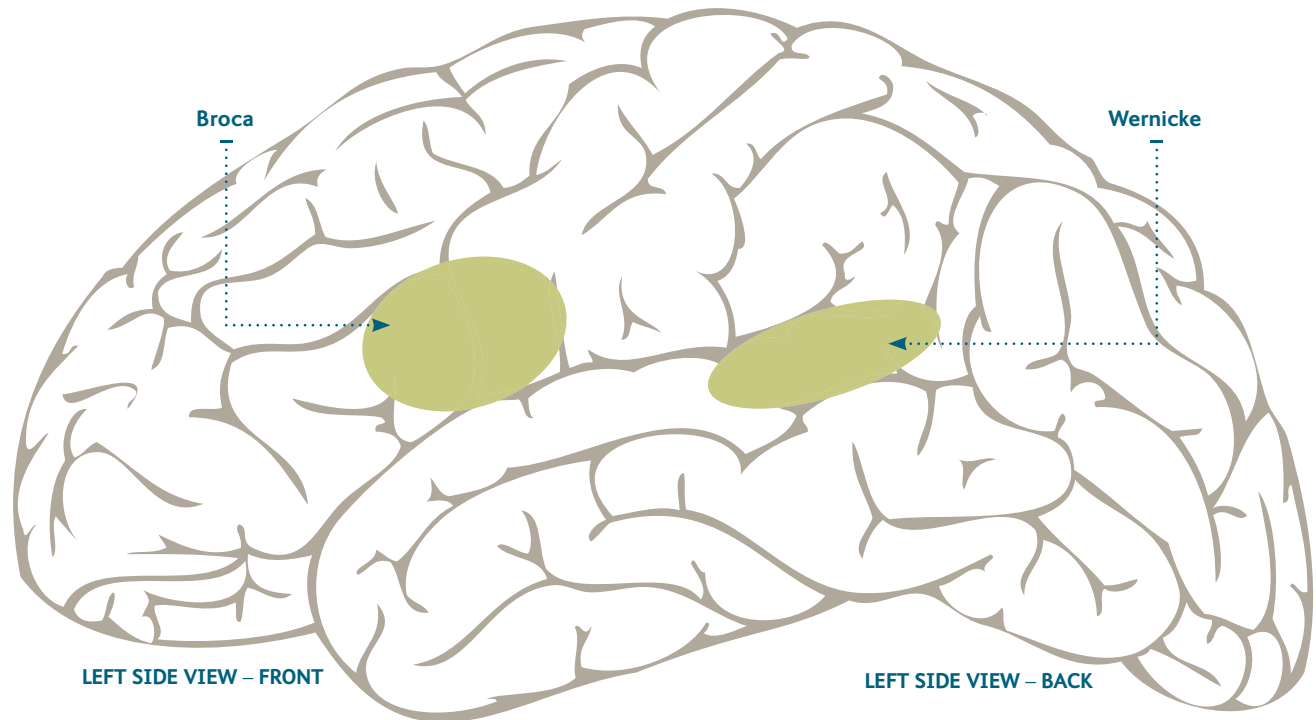
Scientists think that our emotions are produced deep in a part of the brain known as the **limbic system**. An important part of the limbic system is the **hypothalamus**, which regulates pain, pleasure, sexual arousal, anger, hunger, pulse, blood pressure, body temperature and breathing. Also important are groups of neurons that make up the **amygdala**, which is thought to play a role in the formation and storage of memories associated with emotional events. An emotional trigger, such as saying goodbye to someone you won't see for a long time, causes a complex process in the brain that results in a release of hormones into the body. This in turn causes the physiological responses described above.

Related to this is our so-called **fight-or-flight response** to stress. When we perceive a threat, the trigger is relayed through our brain resulting in a release of adrenaline from our adrenal glands (found on top of our kidneys). This causes symptoms including rapid increases in our heart rate and rate of breathing and an increased flow of blood to our muscles, priming us to either fight or flee the perceived threat.

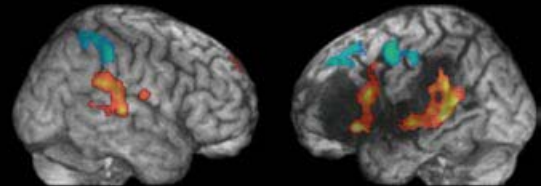
happy  
sad  
angry  
frustrated  
despairing  
amused  
content  
scared  
elated  
surprised  
confused

## Speech and language

Language is mainly processed in the left side of the brain in most people. There are two areas that are particularly important – called **Broca's area** and **Wernicke's area**. People with damage to Wernicke's area can hear language being spoken but have difficulty understanding it, whereas people with damage to Broca's area have trouble speaking sensibly – but can often produce grammatically incorrect and meaningless sentences.



MRC Research Professor Lorraine K Tyler directs the Centre for Speech, Language and the Brain at the University of Cambridge. Her group carries out studies of how brain damage through stroke, and brain changes in healthy ageing, affect the ability to speak and understand language. The aim of the research is to understand the degree to which specialised neural networks are involved in language function and the extent to which they are capable of reorganisation following neural change – either as a function of brain damage or the process of healthy ageing.



This fMRI scan shows brain activity in a healthy person as he processes speech (in orange). The blue shows brain activity of a stroke patient with damage to the language areas of the brain, who was no longer able to interpret grammar. The stroke patient's brain activity doesn't overlap with the healthy person's, showing that the language areas have to be intact in order to process language.

## Memory

Memory is our ability to encode, store and retrieve information. Scientists believe that there is not one place in the brain where memory is stored, but that different types of memory are stored in different places right across the brain. This information has come from studying patients and animals with damage to certain areas of their brains, as well as by taking pictures of people's brains using techniques like fMRI scanning while they are asked to carry out different memory-related tasks.

Memory is still not completely understood, but scientists think there are three distinct types. These are sensory memory, short-term memory and long-term memory. Before any information can become part of our long or even short-term memory, it is stored briefly in our **sensory memory**. This type of memory is lost after less than a second, unless it is passed to our short-term memory.

Our **short-term memory** is where we store small amounts of information for short periods – up to 45 seconds. Scientists estimate that we can typically only store around four or five pieces of information in short-term memory, although this can be increased if the information, such as a phone number, is 'chunked' into groups. A specific type of **short-term memory** is called **working memory**. This is the memory used to help manipulate information, such as when multiplying two numbers.

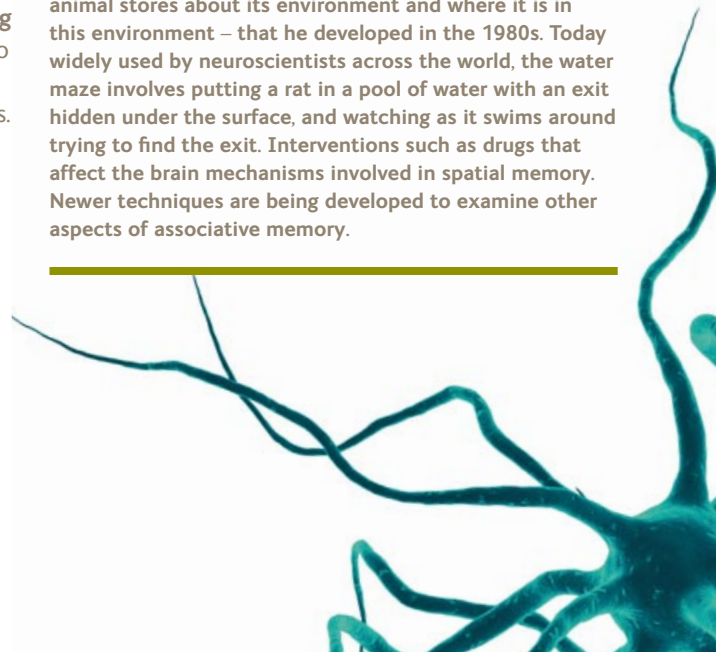
**Long-term memory** differs structurally and functionally from sensory or short-term memory. It can last anything from 30 seconds up to an entire lifetime. There are two main types of long-term memory: our memory of how to do certain tasks, such as riding a bike or using a knife and fork, and our personal archive of knowledge and experiences.

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A process known as **long-term potentiation (LTP)** is thought to be the basis of **learning and memory** at a cellular level in the brain. When LTP occurs, the strength of signals transmitted across synapses increases, and the next time the brain encounters the stimulus that sparked it the first time, the synapses respond more strongly and create a different pattern of signalling. LTP was discovered more than 30 years ago by Terje Lomo and Tim Bliss, who in 1973 published the first paper in the field. Dr Bliss went on to lead a neurophysiology group at the MRC National Institute for Medical Research (NIMR) until his retirement in 2006. There, his group studied LTP in the hippocampus, using advanced microscope techniques and animal models and animal behaviour experiments to investigate the links between LTP and learning, in a quest to discover how memories are encoded and stored.

Professor Richard Morris is a neuroscientist at Edinburgh University. Supported by the MRC, his team studies the role of the **hippocampus** in **memory formation**. In particular, they are investigating which types of memory involve the hippocampus and what physiological processes are happening as memories are encoded, stored, consolidated and retrieved. They are also investigating whether this field of research can help improve understanding of neurodegenerative diseases, such as Alzheimer's and Parkinson's diseases. One of the methods Professor Morris uses in his work is a 'water maze'. This is a tool for studying **spatial memory** – the memories an animal stores about its environment and where it is in this environment – that he developed in the 1980s. Today widely used by neuroscientists across the world, the water maze involves putting a rat in a pool of water with an exit hidden under the surface, and watching as it swims around trying to find the exit. Interventions such as drugs that affect the brain mechanisms involved in spatial memory. Newer techniques are being developed to examine other aspects of associative memory.

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**Memory loss** is one of the main symptoms of **dementia**, such as Alzheimer's disease. The first symptom of the disease is often mild forgetfulness, but as it progresses this forgetfulness begins to interfere with daily activities and sufferers begin to forget how to do simple tasks like brushing their teeth or have difficulty remembering familiar people and places. Alzheimer's disease is caused by abnormal protein plaques and tangles of fibres in the brain. These cause neurons in parts of the brain crucial for memory and other mental tasks to die, and disrupts connections between neurons.

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The MRC Centre for Neurodegeneration Research opened at King's College London in 2006. It aims to improve understanding of the signs and symptoms of **Alzheimer's disease**, **vascular dementia** and **motor neuron disease** and to translate these findings into new ways to diagnose and treat the conditions. Director of the centre, Professor Brian Anderton, said: "The symptoms of neurodegenerative diseases often overlap, suggesting that there may be a continuum of neurodegenerative states. There is therefore an urgent need to find 'biomarkers' of these diseases, particularly ones that can be used in the early stages for diagnosis."

Dr Phil Barnard at the MRC Cognition and Brain Sciences Unit in Cambridge is collaborating with Dr Linda Clare at the University of Bangor in Wales to investigate how 'SenseCam' – a mini camera developed by Microsoft, can help Alzheimer's patients to remember events. The camera is worn like a necklace and records the day's events, playing them back rapidly as a short movie of that day.

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**Prion diseases**, such as Creutzfeldt-Jakob disease (CJD) in humans or BSE in cattle (sometimes known as mad cow disease), are neurodegenerative diseases. Their symptoms include memory loss, personality changes and problems with movement and they are always fatal. Prions are small proteins that exist in two forms – healthy and mutated. In people with prion disease, it's thought that the mutated version accumulates in the brain and causes brain cells to die.

The MRC Prion Unit at University College London is working to improve understanding of **prion disease** and to increase knowledge about the wider relevance of prion-like molecules in neurodegeneration. They are also trying to develop better ways of diagnosing and treating prion disease.

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## Senses

### Sight

Our eyes are connected to our brain through the **optic nerve**. This relays the patterns of light that hit the receptors in our eyes back to the brain, where they are processed and transformed into visual images.

### Hearing

Although the ear is involved in important initial processing of sounds, it is the brain that is primarily responsible for listening – particularly to speech. The **auditory nerve** carries signals from the ear to the brain, where they combine with signals from the other senses – such as vision – where they are processed so that we can hear. As well as sensory input, the auditory brain is strongly influenced by cognitive factors such as attention, memory and learning.

### Touch

There are different types of nerves in our skin, joints, muscles and bones. These send messages to convey touch, pain, pressure, temperature and movement of body parts through our spinal cord into a special part of the brain called the **somatosensory cortex**.

### Smell and taste

We have specialised organs for taste and smell that are known as **chemoreceptors**. These respond to chemical changes on the tongue or in the upper part of the nose to affect our appetite, saliva flow and secretions of fluids in the stomach. They also help us avoid harmful substances.

There are around 10,000 taste buds, found mostly on the tongue. Taste is divided into four basic groups – sweet, salty, bitter and sour, with taste bud receptors in each group working slightly differently. The signals of different tastes are received by a specific region of the somatosensory cortex.

Our sense of smell is due to receptor cells in the upper part of our nose – these are connected via the **olfactory nerve** to the brain.

#### STORIES OF DISCOVERY: NEWBORN HEARING SCREENING

The NHS newborn hearing screening programme, introduced in 2002, improves the early detection of hearing difficulties in babies, allowing earlier and more effective treatment for the 900 babies born each year in the UK with permanent hearing loss.

[www.mrc.ac.uk/Achievementsimpact/Storiesofimpact/Hearingscreen](http://www.mrc.ac.uk/Achievementsimpact/Storiesofimpact/Hearingscreen)

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“Over the past 20 years there has been an explosion in knowledge about the different visual areas in the visual cortex of the brain and the interactions between them,” said Professor Alan Cowey of the University of Oxford. “Up to 50 of these areas make up around one fifth of the cortex in humans and monkeys.” Professor Cowey studies how they contribute to our awareness of different **visual characteristics** (for example colour or motion) and how information processed by each area is integrated to give us a unified and seamless experience of the world. In a new project, Professor Cowey’s team is using different methods – brain imaging, electrical stimulation of the brain, investigation of patients with specific types of brain damage and studies of animal brains – to try to better understand the specific functions of these visual areas. The work may also help explain how the brain adjusts to severe damage, either spontaneously or through rehabilitation.

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The MRC Institute of Hearing Research, with centres in Nottingham, Glasgow and Southampton, is at the forefront of study into the causes, consequences and treatments of **hearing loss**. When current director Professor Dave Moore took the helm in 2002, the unit began to focus more strongly on the ‘auditory brain’, or the role of the brain in hearing. Its work includes studying how signals generated in the ear combine with signals from the other senses in the brain to form the basis of perception. It is also investigating the role of cognitive factors such as attention, memory and learning in hearing. A third focus is on understanding the different things that go wrong in people with hearing problems, and developing tools and techniques to treat them. Another major project involves studying auditory processing disorder – a little-understood problem that causes people with normal hearing to have listening difficulties.

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## Movement

Thousands of muscle cells make up one **muscle fibre**, which can be anything from a millimetre to several centimetres long. In turn, thousands of muscle fibres form the building blocks for our 600 or so **skeletal muscles**. Our brain controls our movement by sending messages to these skeletal muscles telling them to contract or relax as they are needed. This is what enables us to walk, talk, speak, write, play the piano or paint. Our senses provide a feedback mechanism so that our brain can make sure the movement it is controlling happens just how it was planned, and correct any incorrect actions. What's more, these seemingly simple tasks rely on a complex train of biochemical signals that happen almost automatically, without us having to think consciously about what we are doing.

Movement is controlled by a part of the brain called the **primary motor cortex**.

It is helped by various other areas of the cortex, depending on the part of the body being moved.

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Professor Tipu Aziz and colleagues at Oxford University are researching how underactivity in a region of the brain called the pedunclopontine nucleus plays a part in akinesia; a symptom of Parkinson's disease where patients have difficulty in starting to move. The research team rendered macaque monkeys parkinsonian to produce the symptoms of akinesia, then stimulated the pedunclopontine nucleus of the monkey's brains with implanted electrodes. After treatment, the symptoms were reversed, and the monkeys showed improvements in being able to start to move, especially when the brain stimulation was combined with treatment with anti-parkinsonian drugs. This work is now the subject of clinical trials in Toronto, London, Oxford, Bristol, Rome, Grenoble and Brisbane.

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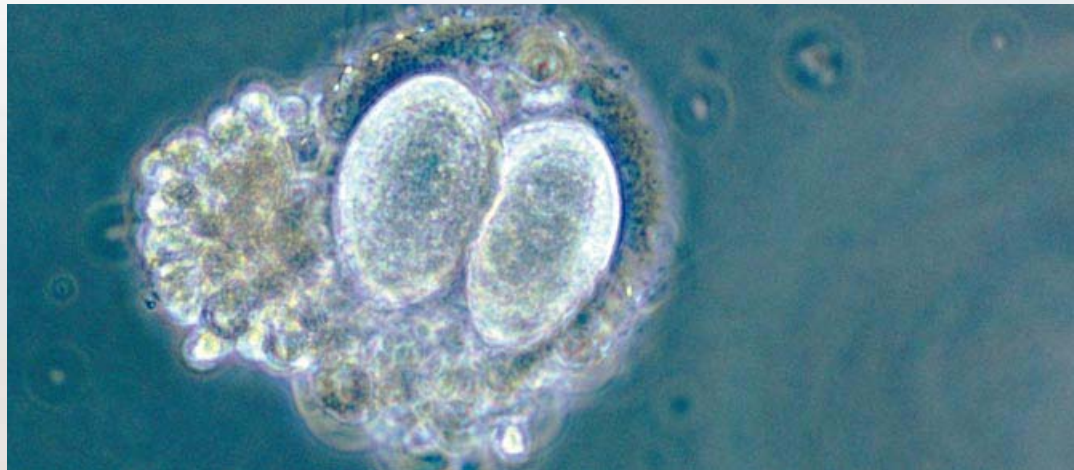


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Movement difficulties, due to diseases such as stroke, developmental problems and neurodegenerative diseases like **Parkinson's disease**, affect one in 20 people at some point in their lives. Most of these conditions appear to involve functional changes in parts of the brain called the basal ganglia – inaccessible centres deep within the brain. Professor Peter Brown and colleagues at UCL's Institute of Neurology are using a technique called deep brain stimulation to try to understand how abnormalities in the basal ganglia contribute to Parkinson's disease. Their goal is to find out how the basal ganglia interact with each other and with other structures such as the cortex in organising normal movement and contributing to abnormal movement. They hope that the results will lead to the development of better treatments.

Professor Philip Bath at Nottingham University is trying a different method to tackle **stroke** – using revolutionary stem cell treatment. His team have discovered that bone marrow stem cells may be able to repair the damage done to the brain by a stroke. Many patients lose the ability to move after a stroke because nerve cells in the brain die while the oxygen supply is cut off. Stem cells have the potential for treating such brain damage by helping to grow new cells. In a pilot study, Professor Bath and colleagues used a drug called granulocyte-colony-stimulating factor to release bone marrow stem cells in 36 patients who had recently had a stroke. They found that the method did not cause any harmful side effects. The next steps are to explore whether these stem cells are able to travel to the brain and to see if they can be directed to repair stroke damage when they get there.

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#### STORIES OF DISCOVERY: DEEP BRAIN STIMULATION

A remarkable surgical procedure that may relieve the symptoms of Parkinson's disease involves electrically stimulating specific parts of the brain. It is considered the most important development in Parkinson's treatment since the 1960s.

[www.mrc.ac.uk/Achievementsimpact/brainsenses](http://www.mrc.ac.uk/Achievementsimpact/brainsenses)

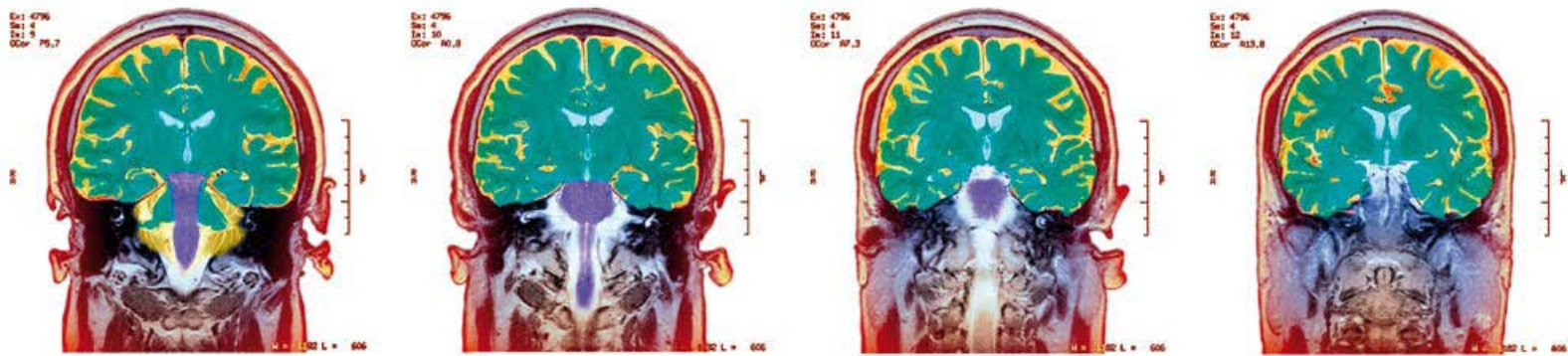
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## Mental health

Illnesses, such as depression, anxiety, schizophrenia, autism and behavioural problems are very common. Many MRC scientists across the UK are working to try to understand what happens in the brain when these illnesses occur, and what can be done to combat them. There is still a lot of stigma associated with mental health problems. Improving understanding of these illnesses and their causes is one way to combat this.

To find out more about work being done in the UK to reduce the burden of mental illness, see the Royal College of Psychiatrists ([www.rcpsych.ac.uk](http://www.rcpsych.ac.uk)) and the Department of Health ([www.dh.gov.uk/en/Policyandguidance/Healthandsocialcaretopics/Mentalhealth](http://www.dh.gov.uk/en/Policyandguidance/Healthandsocialcaretopics/Mentalhealth)).



## Depression

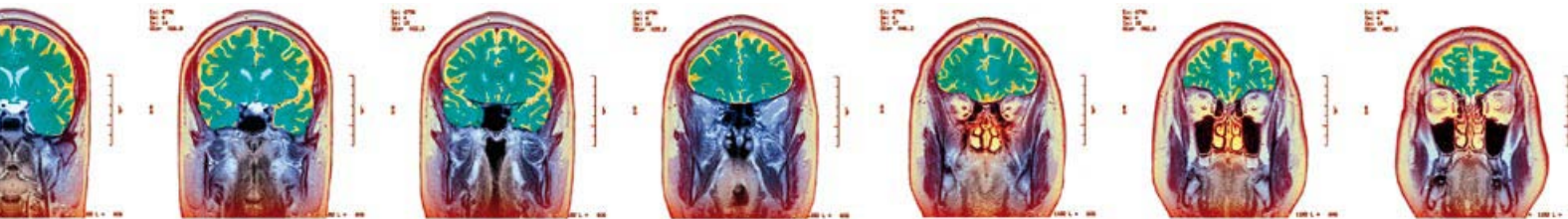
Depression affects at least one in every six people at some point during their lives. As well as causing extreme feelings of sadness or hopelessness that persist for a long time, it often also has physical symptoms, such as difficulty sleeping, tiredness and a loss of energy, change in appetite and weight loss or gain, and physical aches and pains. Levels of the neurotransmitters serotonin and noradrenalin are thought to be altered in the brains of many people with depression.

Around one in 10 people with depression also has periods of elation – this is known as manic depression, or bipolar affective disorder. Some women suffer from depression after giving birth – postnatal depression – and some people develop what's known as seasonal affective disorder caused by a lack of sunlight during the winter months.

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Several MRC-funded studies aimed at combating **depression** are currently underway. For instance, Professor Glyn Lewis at the University of Bristol is carrying out a large clinical trial (GENPOD) comparing two different types of antidepressant in patients with depression. He is assessing whether any genetic, clinical or hormonal factors predict how patients will respond to treatment.

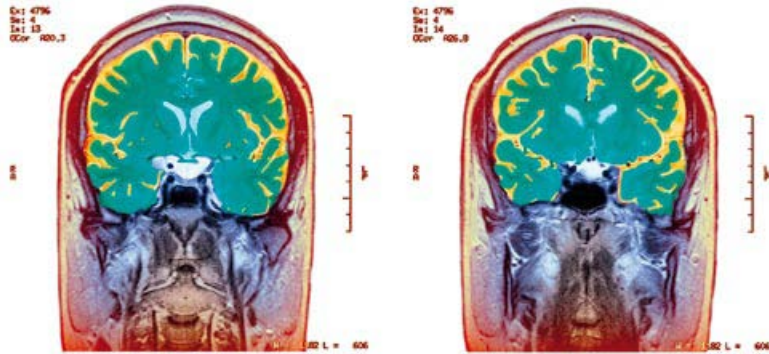
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## Anxiety

Everyone feels anxious or worried from time to time. But some people may feel worried for long periods of time and find that it interferes with their life and prevents them from doing things. Called generalised anxiety disorder, this can be successfully treated.

Obsessive-compulsive disorder is also classed as an anxiety-related illness. It's characterised by obsessive, disruptive thoughts or repetitions of an activity, such as washing one's hands or checking the door is locked. Other types of anxiety problems include phobias (an irrational persistent fear of something) and post-traumatic stress disorder, which can develop after the sufferer has experienced a traumatic event.



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Patients who suffer from **anxiety** are usually treated with drugs or psychological therapy (usually cognitive behavioural therapy). Even though the two treatments are often given together, most research has looked at them individually. Dr Catherine Harmer at the University of Oxford is addressing this by studying the integration of drug treatment and cognitive behavioural therapy. She hopes that the work will help to optimise combination treatment.

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## Addiction

Addiction occurs when a person becomes dependent on something to get through day-to-day life. It can be caused by both physical and psychological dependency.

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At the University of Cambridge Behavioural and Clinical Neuroscience Institute, jointly supported by the MRC and the Wellcome Trust, Professor Barry Everitt is studying the neural and psychological processes that underlie **drug addiction**. A major part of his research is the impact of learning on drug addiction. Taking drugs might begin as a voluntary action, but over time it can turn into a compulsive habit that is extremely difficult to give up. Professor Everitt's team has begun to work out the brain processes that occur during transition from initial drug use to addiction. The team has also discovered that memories of drug use become changeable when they are retrieved and must be restabilised through a process known as reconsolidation. The scientists believe that removing or disrupting these memories at the time of retrieval might hold promise for preventing relapse which is often triggered by the recall of vivid drug-associated memories.

In the same group, Dr Jeffrey Dalley is investigating whether a type of behaviour called 'trait impulsivity', which makes individuals more prone to impulsive actions, is linked to drug addiction. He has studied changes in receptors for dopamine – a neurotransmitter that affects emotion, perception and movement – in rats' brains. Rats that had not previously been exposed to cocaine but were naturally impulsive had fewer dopamine receptors and were more likely to escalate their self-administration of cocaine when given the chance. "The results show promise for helping to identify individuals most at risk of developing a drug abuse problem," said Dr Dalley.

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## Autism

Autism is a developmental disability that affects the way a child or adult communicates and relates to the people around them. It is thought to encompass a range of different conditions that are known as **autistic spectrum disorders**. It's estimated that up to one per cent of school age children have some form of autism, making it more common than childhood cancer, diabetes, and AIDS combined. It occurs in all racial, ethnic, and social groups and is four times more likely to affect boys than girls.

People with **autism** have difficulties with communication and social interaction. The condition is also characterised by a preference for rigid routines and repetitive behaviours. It causes severe delays in development and affects a person's ability to develop friendships and their capacity to understand other people's feelings. It is associated with significant costs – estimated at £28 billion every year in the UK – and can be very distressing for individuals with autism and their families.

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The MRC funds many scientists who are researching **autistic spectrum disorders**. For instance, funded by the MRC throughout her career, Professor Uta Frith recently retired from the Institute of Cognitive Neuroscience at UCL. In the 1980s she proposed that people with autism have an impaired "theory of mind", that is, specific difficulties in understanding other people's beliefs and desires.

The condition is known to have a strong genetic element and this is a major research focus today. Professor Anthony Monaco of the University of Oxford's Wellcome Trust Centre for Human Genetics is part of a worldwide study of the largest ever collection of families with multiple cases of autism. Aiming to improve understanding of the genes that put people at risk for autism, the study could lead to improved diagnosis, new targets for therapy and new theories about the mechanisms underlying the disease. Delving into the interplay between genes and the environment in children with autism is the focus of researchers at the MRC Social, Genetic and Developmental Psychiatry Centre at the Institute of Psychiatry in London (see page 12).


Other MRC scientists are carrying out research into social cognition and autism. Professor Mark Johnson at Birkbeck, University of London is interested in the development of babies' brains during the first years of life. In particular, his team's work is focusing on how specialised cognitive functions emerge within particular brain regions during development. Professor Tony Charman at the UCL Institute of Child Health is trying to find ways to apply knowledge about differences in social cognition in autism, to help develop methods for screening and earlier treatments and to set up long-term population studies.

At the University of Manchester, Professor Jonathan Green is leading a clinical trial of a new pre-school treatment for autism. The study, involving children aged between two and five, is testing a method to improve their social and language development and to improve communication with their parents.

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## Psychotic disorders

Psychotic disorders are serious illnesses that alter someone's ability to think clearly, make judgements, understand reality and communicate properly. Most common are schizophrenia and related conditions. Other types of psychotic illness include brief psychotic disorder, characterised by sudden and brief periods of psychotic behaviour, usually in response to a trauma, and delusional disorder, in which people have real-life delusions such as having a disease or being conspired against.



Professor Eve Johnstone of the University of Edinburgh studies images of the brains of **schizophrenia** patients to learn more about the condition. She has been working on schizophrenia for 33 years, trying to understand its biological basis. In 1976 her team was the first to demonstrate that there were actual structural faults in the brains of schizophrenic patients. More recently, 10 years of monitoring 200 young people at risk of the illness using fMRI scanners (see page 9) showed that this can predict that someone will develop schizophrenia even before they develop any symptoms.

#### STORIES OF DISCOVERY: SCHIZOPHRENIA

Schizophrenia is a very common mental illness. It affects one in 100 people in the UK at some point during their lives. You can read more about the history of schizophrenia research and find out how MRC researchers are investigating the condition and what causes it and how to treat and prevent it.

[www.mrc.ac.uk/Achievementsimpact/Storiesofimpact/Schizophrenia](http://www.mrc.ac.uk/Achievementsimpact/Storiesofimpact/Schizophrenia)



# Glossary

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## **Afferent neuron**

Nerve cells that transmit information from the tissues and organs of our body into the central nervous system.

## **Amygdala**

A part of the brain thought to play a key role in emotion.

## **Arachnoid**

The middle layer of the meninges, which has a spider web-like appearance and plays a role in protecting the brain.

## **Auditory nerve**

Also called the cochlear nerve, this carries sound information from the ear into the brain where it is processed.

## **Brain stem**

The part of the brain that controls processes essential for life, such as consciousness and breathing. It receives and relays messages from all parts of the central nervous system.

## **Broca's area**

A part of the brain in the cerebral cortex that's involved in speech and language. People with damage to this area may have difficulty creating grammatically correct sentences.

## **Central nervous system**

The brain and the spinal cord

## **Cerebellum**

The part of the brain responsible for learning movement and controlling posture and balance. It receives information from our muscles, joints, skin, eyes, ears and other parts of the brain involved in movement.

## **Cerebral cortex**

The largest part of the brain, controls processes such as memory, learning and movement.

## **Cerebrospinal fluid**

Liquid which fills in the gaps around the brain to protect and cushion it.

## **Cerebrum**

This is what most people think of as the brain – it's the largest part of the brain that sits on top of the brainstem and is the most well-developed of the five regions of the brain.

## **Corpus callosum**

A massive bundle of nerve fibres that connects the left and right hemispheres of our brain.

## **Dura**

The outermost layer of the meninges – a thick durable membrane that contains large blood vessels that supply the brain and spinal cord with food and oxygen. It also supports two large veins that carry blood from the brain back into the heart.

## **Efferent neuron**

Nerve cells that transmit information from the brain and spinal cord (central nervous system) into our body, for example, to tell our muscles to contract.

## **Functional imaging**

Real time imaging of the brain, such as functional MRI, which allows scientists to study the brain in action.

## **Glial cells**

Cells that provide support, protection and nourishment for neurons.

## **Grey matter**

The areas in the brain made up mostly of the cell bodies of neurons.

## **Hippocampus**

Part of the forebrain, it plays a role in long-term memory and spatial navigation.

## **Hypothalamus**

The brain's control centre for regulating our body's internal environment and keeping us alive – including eating, drinking and reproduction.

## **Interneuron**

Nerve cells that provide connections within the central nervous system.



### **Limbic system**

A set of brain structures including the amygdala and hippocampus, which support functions including emotion, behaviour and long-term memory.

### **Meninges**

Three tough membranes that surround and protect the brain.

### **Motor cortex**

The part of the cerebral cortex that controls motor functions (movement).

### **Neurodegeneration**

The progressive loss of structure or function of neurons, which occurs in diseases such as Alzheimer's and Parkinson's.

### **Neuron**

Also called nerve cells, these are the cells in the brain and nervous system that transmit and process information.

### **Neurotransmitter**

Chemicals that are used to relay messages between neurons.

### **Peripheral nervous system**

The nerves connected to the central nervous system (brain and spinal cord) which carry messages to and from the rest of our body.

### **Pia**

The innermost layer of the meninges (see above) – a delicate membrane made from a thin fibrous tissue. It follows the contours of the brain and spinal cord and has capillaries that provide food and oxygen to the brain.

### **Pituitary**

Sometimes known as the 'master gland' of hormonal regulation, the pituitary is located at the base of the brain and sends signals that regulate growth, metabolism and reproduction.

### **Plasticity**

The ability of the brain to change and adapt. It is this characteristic that allows people to relearn things like walking and talking even after the parts of their brain responsible are damaged beyond repair.

### **Prion disease**

Prions are small proteins that exist in two forms – healthy and mutated. In people with prion disease, it's thought that the mutated version accumulates in the brain and causes brain cells to die.

### **Sciatic nerves**

Nerves which run the entire length of our legs (part of the peripheral nervous system).

### **Spinal cord**

A long tube-like structure that's made of long nerve fibres that pass messages between the brain and the rest of the body.

### **Structural imaging**

Ways of taking pictures of the brain that allows scientists to study its structure and diagnose problems such as tumours or brain injury.

### **Subarachnoid space**

The space between the two innermost layers of the meninges which is filled with cerebrospinal fluid.

### **Synapse**

The space between two adjacent neurons.

### **Thalamus**

Part of the brain that plays a key role in integrating inputs to the cerebral cortex

### **Wernicke's area**

An area of the brain in the cerebrum that's involved in understanding speech and language.

### **White matter**

The areas of the brain made up mostly of the axons that connect nerve cells.

# Safeguarding ethical standards

Scientists study the brain in many ways, from research in the lab to studies involving animals and clinical trials testing new therapies in people. Like any area of medical science, new lines of investigation can raise ethical dilemmas. Any justifiable concerns that the public may have must be balanced with the need for scientists to proceed as efficiently as possible with essential research into life-threatening diseases.

All UK medical research involving people, their tissue or data must be approved by a research ethics committee before funding can be granted and the research may begin. These committees are completely independent of scientists and their potential funders.

The MRC also has its own Ethics Regulation and Public Involvement Committee, which provides expert ethical policy advice on a wide range of issues relating to medical research. All the scientists we fund must comply with UK legislation and follow MRC and other relevant codes of practice, to ensure that their research is carried out according to high ethical standards. The MRC is the leading source of guidance and advice in the area of research ethics and produces a wide range of guidelines on ethics and best practice for medical researchers.



## MENTAL CAPACITY ACT

The Mental Capacity Act 2005 for England and Wales came into force in October 2007. For the first time it sets out in law a framework for carrying out research involving adults who are unable to make decisions for themselves, such as those who are unconscious, have severe learning difficulties or have mental health problems. At the heart of the Act is the assertion that adults should be assumed to have the capacity to make their own decisions unless it is proven otherwise. Research in adults without mental capacity must be approved by a research ethics committee, which will assess whether the research is related to the condition causing incapacity, if it could be done in adults who do have capacity instead, and if it would benefit the participant. The Act also details who must be consulted before adults who lack capacity may be recruited to a study.

The MRC has produced an ethics guide, *Medical research in adults who cannot consent*, for researchers on carrying out research under the Mental Capacity Act 2005. You can download a copy at [www.mrc.ac.uk/newspublications/publications/ethicsandguidance](http://www.mrc.ac.uk/newspublications/publications/ethicsandguidance).

# Working with you

**The public plays an essential part in the work of the MRC.** Following are some examples of how you can get involved in what we do.

## Take part in clinical trials

New medical treatments or therapies must go through a series of clinical trials before they can be used by doctors or other healthcare professionals. Any new drug must go through several stages of tests for safety and effectiveness as it gets nearer the market. These trials will include comparisons with either placebo (sugar pills or similar) or the current best treatment for a condition.

The patients and other members of the public who volunteer to take part in these trials are helping to advance medical science for the benefit of everyone in the community. The UK Clinical Research Collaboration, of which the MRC is a partner, produced a booklet in 2007 to explain what clinical trials are and how and why they are carried out. It is designed to answer the many questions people may have when deciding whether to take part in a trial. You can download or request a copy of the booklet at [www.ukcrc.org/publications/informationbooklets.aspx](http://www.ukcrc.org/publications/informationbooklets.aspx).

## Help scientists link lifestyle with disease

UK Biobank is a multi-million pound project that aims to help researchers find ways to improve the prevention, diagnosis and treatment of many common illnesses that affect older people. Such diseases include cancer, heart disease, diabetes, dementia and mental illness. UK Biobank is building up comprehensive data about the health and lifestyle of 500,000 people aged between 40 and 69, who will be tracked for at least 20 or 30 years. The involvement of these people, who will supply DNA samples and health and lifestyle information throughout the course of the study, is vital to the success of the project. For more information, visit [www.ukbiobank.ac.uk](http://www.ukbiobank.ac.uk).

## Help the MRC find out what the public thinks

Since 2000, the MRC has used advisory groups to help develop ways of promoting effective and appropriate public involvement in our activities. These groups also help us to make sure that we are responsive to the public's interests and concerns about medical research. Our Public Panel is a way of matching suitable lay people with specific MRC activities in which a patient or public perspective would add value, on a project-by-project basis. The Panel is made up of people who have an interest or lay expertise in some aspect of medical research – perhaps by association with a medical charity or through personal experience. To find out more, visit [www.mrc.ac.uk/sciencesociety/publicinvolvement/publicpanel](http://www.mrc.ac.uk/sciencesociety/publicinvolvement/publicpanel).

# Find out more

If you would like to find out more about MRC-funded research into the brain, visit our website or the websites of our units, institutes and centres working in brain research. You can visit any of the other websites on this page to find out more about different perspectives on neuroscience, including about conditions that affect the brain and mind.

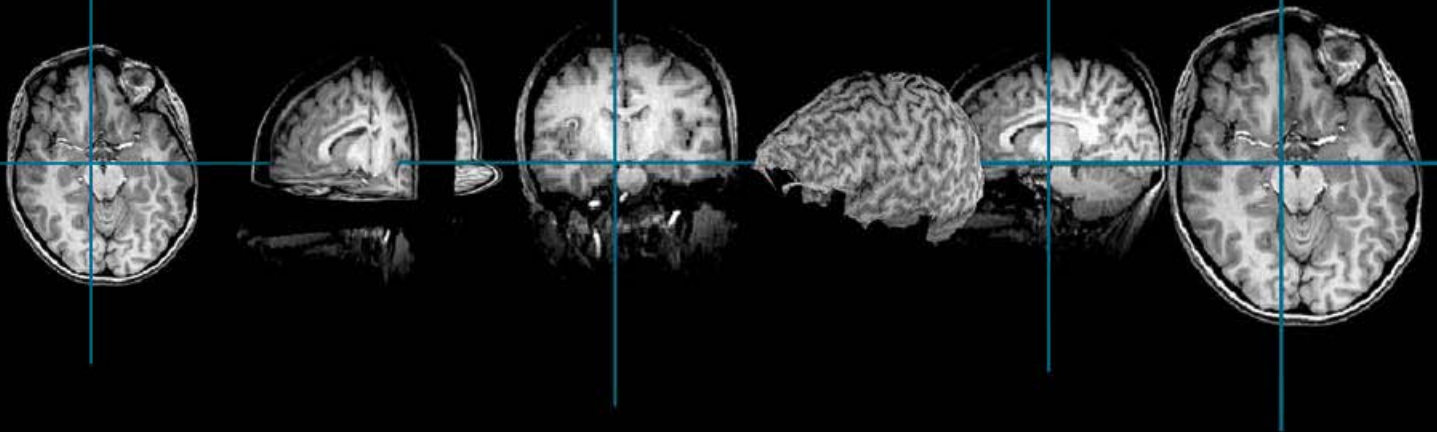
## Useful web links

- » **Medical Research Council** [www.mrc.ac.uk](http://www.mrc.ac.uk)
- » Alzheimer's Research Trust [www.alzheimers-research.org.uk](http://www.alzheimers-research.org.uk)
- » Alzheimer's Society [www.alzheimers.org.uk](http://www.alzheimers.org.uk)
- » Behavioural and Clinical Neuroscience Institute <http://research.psychol.cam.ac.uk/~bcni/>
- » Brain Injury Rehabilitation Trust [www.birt.co.uk](http://www.birt.co.uk)
- » Cambridge Brain Sciences [www.cambridgebrainsciences.com](http://www.cambridgebrainsciences.com)
- » Headway – the brain injury association [www.headway.org.uk](http://www.headway.org.uk)
- » Mental Health Foundation [www.mentalhealth.org.uk](http://www.mentalhealth.org.uk)
- » MIND (National Association for Mental Health) [www.mind.org.uk](http://www.mind.org.uk)
- » Motor Neuron Association [www.mndassociation.org](http://www.mndassociation.org)
- » MRC Anatomical Neuropharmacology Unit <http://mrcanu.pharm.ox.ac.uk>
- » MRC Centre for Developmental Neurobiology, King's College London [www.kcl.ac.uk/depsta/biomedical/mrc](http://www.kcl.ac.uk/depsta/biomedical/mrc)
- » MRC Centre for Neurodegeneration Research at the Institute of Psychiatry, King's College London <http://cnr.iop.kcl.ac.uk>
- » MRC Clinical Sciences Centre [www.csc.mrc.ac.uk](http://www.csc.mrc.ac.uk)
- » MRC Cognition and Brain Sciences Unit [www.mrc-cbu.cam.ac.uk](http://www.mrc-cbu.cam.ac.uk)
- » MRC Institute of Hearing Research [www.ihr.mrc.ac.uk](http://www.ihr.mrc.ac.uk)
- » MRC Laboratory of Molecular Biology <http://www2.mrc-lmb.cam.ac.uk>
- » MRC National Institute for Medical Research [www.nimr.mrc.ac.uk](http://www.nimr.mrc.ac.uk)
- » MRC Prion Unit [www.prion.ucl.ac.uk](http://www.prion.ucl.ac.uk)
- » MRC Social, Genetic and Developmental Psychiatry Centre [www.iop.kcl.ac.uk/iopweb/departments/home/default.aspx?locator-10](http://www.iop.kcl.ac.uk/iopweb/departments/home/default.aspx?locator-10)
- » MRC/University of Bristol Centre for Synaptic Plasticity [www.bris.ac.uk/Depts/Synaptic](http://www.bris.ac.uk/Depts/Synaptic)
- » Multiple Sclerosis Society [www.msssociety.org.uk](http://www.msssociety.org.uk)
- » Parkinson's Disease Society [www.parkinsons.org.uk](http://www.parkinsons.org.uk)
- » Rethink [www.rethink.org](http://www.rethink.org)

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- » SANE [www.sane.org.uk](http://www.sane.org.uk)
  - » Stroke Association [www.stroke.org.uk](http://www.stroke.org.uk)
  - » University of Edinburgh Centre for Cognitive Ageing & Cognitive Epidemiology [www.ccace.ed.ac.uk](http://www.ccace.ed.ac.uk)
  - » University of Newcastle Centre for Brain Ageing & Vitality [www.ncl.ac.uk/iah/about/campus](http://www.ncl.ac.uk/iah/about/campus)

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