PENNY FIDLER

The silent epidemic

Penny Fidler is carrying out research on the brain for her PhD. Much of our understanding of the brain and the nervous system has come from studying the effects of damage to these organs. In this article Penny gives some examples of how damage affects brain and nervous system function.

Every week in Britain, over 100 people are involved in accidents that leave them with severe and permanent brain damage. But this is the tip of the iceberg. Thousands more each week are injured by strokes or brain diseases, producing damage that will last a lifetime. Likewise, damage to the spinal cord is permanent, often causing paralysis and a life confined to a wheelchair.

If we break a bone or gash our skin, cells divide to replace those lost. So why is it that an organ as vital as the brain cannot repair itself after injury? The reason is that, unlike most cells of the body, which divide to produce copies of themselves, nerve cells will never divide again after birth, and so lost nervous tissue cannot regenerate.

HEAD INJURY

Head injuries can occur for many reasons. Car crashes, falls and assaults are the most common. If the skull is cracked, pieces of bone may dig into and tear the brain, causing irreparable damage. But brain damage can easily occur when the skull is unbroken. Hitting the head can lead to bruising and damage of the soft brain tissue, or worse, the brain can bleed or swell. Swelling is dangerous because, as the brain gets larger, it presses tightly on the inside of the skull, sometimes squashing areas of the brain that are vital to life. Sometimes a person may appear totally normal after a knock to the head, yet collapse several hours later when the pressure in their skull reaches life-threatening levels.

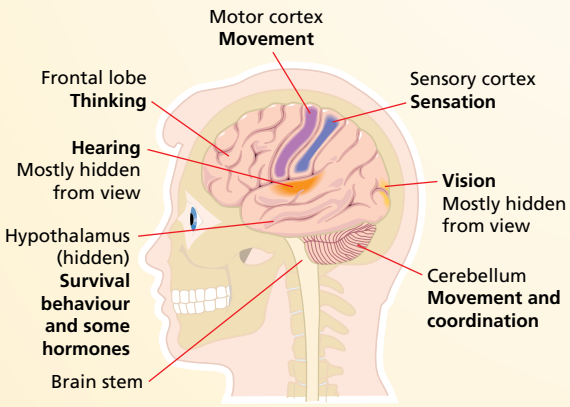

Figure 1 *The main features of the brain.*

BRAIN DISEASES

Sometimes a part of the brain may begin to die for no known reason. This is the case in Alzheimer's disease, which attacks one in 20 people over the age of 65, causing devastating memory loss. Parkinson's disease affects one in 200 people over 65 years old, and destroys a central part of the brain which controls movement. However, the most common cause of brain damage is when part of the brain is starved of oxygen, for example during a stroke.

CUTTING OFF THE ENERGY SUPPLY

The brain has huge energy requirements. It needs a very reliable, constant supply of glucose and oxygen, which is delivered by the blood. When the blood supply fluctuates, such as when you stand up too quickly, minor symptoms such as dizziness are felt. If the blood supply is completely stopped for a few minutes, as in a stroke, brain cells begin to die. The usual cause of a stroke is a diseased blood vessel. A main artery to the brain may be blocked or it may begin to leak. Much of the starved part of the brain dies.

The effects of a stroke vary greatly, depending on where the brain injury is. Damage to the motor cortex (Figure 1), which controls movement, can cause clumsiness, slowness or even paralysis. Frequently the facial muscles droop, and speaking may be slurred. If the brain stem is damaged, the outlook is poor, for this area controls vital functions such as breathing, swallowing and consciousness itself. Even a small injury here may lead to coma and sometimes to death.

Seventy-nine per cent of spinal cord injuries occur to males, most commonly to 19 year olds.

The human nervous system is estimated to contain between 100 and 1000 billion neurons (no one has counted!).

About half our neurons die in the first few years of life, as they are not needed.

Nerve cells in the brain do not divide because it is their stability that is the basis of brain functions such as memory. Learning probably occurs because of the changing nature of the connections between these 'hard-wired' nerves.

The human brain makes up only 2% of the total body weight, yet uses 20% of the oxygen taken into the body.

The brain receives almost a litre of blood every minute.

One person in 150 in Britain lives with the consequences of stroke; that is ⅓ million people.

● Find out the criteria applied by doctors when checking for brain death.

● Find out what cerebral palsy is.

One in 800 adults in Britain has MS.

Nerves outside the brain and the spinal cord can regenerate their axons.

The back page, 'Imaging the brain', describes some ways of looking at brain structure and function.

SEVERING THE 'INFORMATION SUPERHIGHWAY'

All the messages from your brain telling your muscles to move, or the messages travelling in the opposite direction telling your brain about touch and joint position, travel up and down through the spinal cord. If you injure this 'information superhighway', the results are catastrophic. Your brain can no longer communicate with the lower parts of your body. If the injury is low down in the back, you may lose the use of your legs and control of bladder function. A neck injury may sever the connections with the arms as well, causing loss of the use of all four limbs (tetraplegia). It may also block messages to the muscles of the diaphragm, needed for breathing.

Every year in Britain, 800 young people are paralysed as a result of a car accident, a fall, or a sports injury, such as diving into a pool that is too shallow. Nerve cells cannot divide to make copies of themselves after injury. What they can do however, is re-grow their injured axons back down the spinal cord. The problem, it seems, is that where the spinal cord has been injured a scar builds up, which the re-growing axon cannot penetrate. The scar is not just a physical barrier, it also produces chemicals that will stop a re-growing nerve in its tracks.

MULTIPLE SCLEROSIS (MS)

Nerves send messages along their length as electrical impulses. Nerve impulses pass more quickly along neurons that are insulated. Around the time of your birth, specialised cells develop close to each nerve cell, and send out a fatty tendril which slowly wraps itself around the nerve. This creates an insulating myelin sheath. If holes develop later in this sheath, nerve impulses begin to leak out. This is what happens in multiple sclerosis — the body's own immune system begins to chew away the myelin, so that messages from, or to, the muscles are unreliable. The optic nerve, carrying information from the eyes to the brain, is frequently affected and the sufferer's vision becomes poor. The effect of this disease is particularly devastating as it usually strikes people in their twenties, often just as they begin a family of their own.

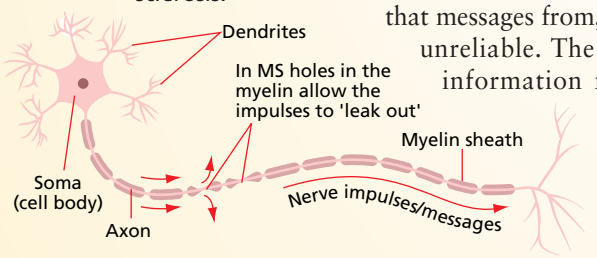

Figure 2 *A nerve cell (neuron) showing the effects of multiple sclerosis.*

BOX 1 A NERVE CELL

Nerve cells can be huge, stretching from the cell body in the brain, all the way down to the bottom of the spinal cord. Although very long (up to 1 metre), they are also very thin (5 μm = 5/1000 mm = 1/200 mm in diameter) and packed tightly together to form nerve bundles. Most of the myelin sheath of the nerve cell in Figure 2 has a normal healthy appearance — in this state the nerve impulse jumps from gap to gap and is transmitted quickly. One stretch has been drawn as it appears in someone with multiple sclerosis — the nerve impulse moves more slowly or may be blocked.

BOX 2 TESTING THE NERVOUS SYSTEM

If a light is shone into one eye, a message is sent to the brain stem, which instructs the circular muscles of both irises to contract, causing both pupils to constrict (get smaller). After a bump to the head, a doctor may test this reflex to check for injury in all the pathways to, from and within the brain stem. (See Figure 3.)

The **knee-jerk** reflex tests that

- ❖ a message is being relayed from stretch receptors in the thigh muscles to the spinal cord, and
- ❖ the message is then returning as an instruction to the muscle, which contracts and causes the leg to kick out.

Any damage to the spinal cord will affect this circuit. A cancerous tumour might also press on the spinal cord and cancel the knee jerk.

A 'slipped disc' can also put pressure on nerves in the spinal cord which come from the leg. This 'referred pain' is felt as pain in the leg (**sciatica**).

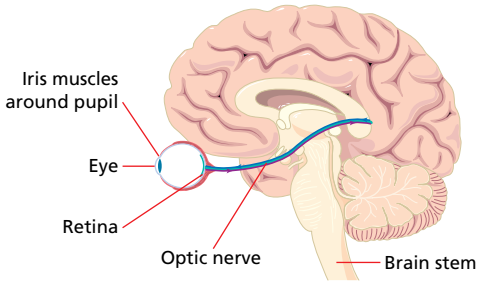

Figure 3 *Testing pupil reflex action for brain stem connections. Impulse is sent to brain stem saying 'too much light entering eye'. Brain stem replies making circular iris muscles contract and reducing pupil diameter.*

CONCLUSION

The brain and spinal cord are so vital to all our bodily functions that if they are injured in any way, either by starving them of oxygen and glucose, by a neurodegenerative disease or by physical trauma that directly cuts the nervous tissue, the result is catastrophic. Scientists from all over the world, are working together to find out:

- how the brain works, and
- ways of making the brain and spinal cord repair themselves after injury.

Perhaps one day paralysis and life-long brain damage will be a thing of the past.

Penny Fidler works at the Medical Research Council Cambridge Centre for Brain Repair. Her research is funded by The Wellcome Trust.