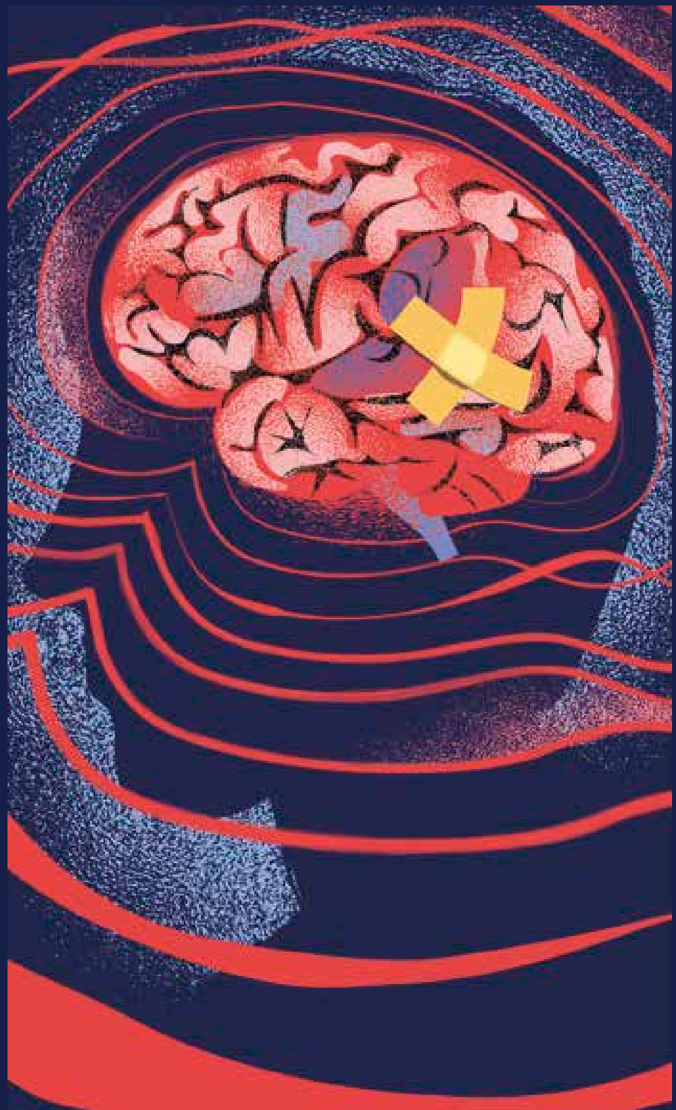

Can the brain heal itself?

HAYLEY BENNETT
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Some animals have incredible regenerative abilities, growing new legs and tails to replace lost ones. Fish and salamanders can even grow new brain cells to repair damaged portions of their brains. As mammals, though, our capacity for regeneration is more limited, particularly where the brain is concerned.

"Lower vertebrates keep on replacing neurons quite happily throughout their life, but mammals don't," explains James Fawcett, a neuroscientist at the University of Cambridge. "We stop making new neurons before birth, pretty much, except for one or two small parts of the nervous system."

This means that whilst we can repair a cut to our skin by growing new skin cells, we can't recover from a brain injury in the same way. Instead, our brain's only option is to work with the existing neurons – cells that carry all the information required for us to think, move and perform our normal bodily functions. If the odd brain cell goes offline here or there, it's not usually a problem, but the impact of a major brain injury depends on the type and site of injury, and how many neurons have been lost.

To some extent, what's left can be remodelled – the brain has what we call 'neuroplasticity'. Think of your brain as if it were Google Maps or another route planner. If one of the roads on the quickest route is being dug up, Google Maps will find you another route, even if it takes a bit longer. Similarly, because each brain cell has thousands of different connections, your brain is capable of some fairly extensive re-routing of its signalling, says Mark Ashley, CEO of the US-based Centre for Neuro Skills, which helps patients to recover from brain and spinal cord injuries. "We may lose a highway or two, or several highways, but theoretically, we could find other highways."

This means when the brain is injured it can try to bypass the damaged cells by forming new connections between neurons in order to drive the lost functions. Neuroplastic processes also occur when we're learning new skills, but with a major brain injury it can result in some dramatic remodelling, even to the extent of entire functions being transferred to different parts of the brain – hearing, for example, can be taken over by the visual cortex, and vice versa. Neuroplasticity relies on the nerve cells themselves, as well as support cells called glial cells that help make new connections and repair myelin, which is the protective covering around a nerve fibre that speeds up nerve impulses.

The nerve fibres (axons) that carry the signals do also have some capacity for sprouting new branches, when the main body of the nerve cell is still intact. As Fawcett explains, though, regeneration of nerve fibres that have been cut, as in a typical spinal cord injury, is restricted by the formation of scar tissue – which hinders regrowth – and normal changes during maturation that stop them regenerating their axons. "There's some genetic programme that goes with maturation that turns off regeneration," Fawcett says. His team of researchers have made some headway in regeneration of axons in the spinal cords of mice and rats, but the fibres are much longer and trickier to regrow in humans.

Rehabilitation programmes focus on getting the most out of the brain's natural neuroplasticity and could involve up to 17 hours per day of therapy – the more intensive the better, Ashley says, as this constant 'demand for function' encourages the brain to rebuild in order to respond.

However, our understanding of the brain is limited enough that trying to predict how a patient will recover based on brain imaging can be futile. "I've adopted the notion that the early predictions of recovery are far more likely to be incorrect than correct," says Ashley, who adds that he's often "pleasantly surprised" by what's achievable, given access to the right treatment.

ILLUSTRATIONS: CHRISTINA KALLI

YOUR MYSTERIOUS BRAIN | FEATURE | SF

Do we really have brain regions?

DR LISA FELDMAN BARRETT
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There's more than one way to carve up a human brain. We could draw lines based on what we see with the naked eye: your brain has two hemispheres, left and right. Or we could peer more deeply with a powerful microscope or sophisticated brain-imaging tools: your brain is a network of nearly 200 billion interconnected brain cells. About two-thirds of them, called neurons, continually talk to each other via electrical and chemical signals throughout the network. The other third, called glial cells, have multiple functions that scientists are still learning about.

We could examine a brain structurally. Neurons can be organised in layers, like in the cerebral cortex, which is traditionally divided into different lobes — frontal (at the front), occipital (at the back), temporal (roughly over your ears), and parietal (the rest). Neurons can also be organised into clumps, which scientists call nuclei, that sit beneath the cerebral cortex; for example, you might recognise the name 'amygdala', which is actually a cluster of 13 nuclei deep within each temporal lobe of your brain. We can also carve a brain up by looking at genetic material inside the brain cells, which reveals something about how your brain evolved and how it was assembled when you were a developing embryo.

Another popular way to slice and dice the brain is by function. An obvious approach is to search for the bits of the brain that allow you to think thoughts, feel emotions, see and read these words, hear music, move your arms and legs, and do all the other things that make you who you are. Thousands of studies reveal that this approach has not worked well, because these sorts of functional designations — such as cognition, emotion, perception, action, and so on — do not represent firm boundaries in the brain. The left side of your brain is not the source of logic, and the right side is not the wellspring of creativity. Rationality does not live in your cerebral cortex, and emotions are not lurking in an ancient beast within the subcortical parts of your brain. At this point, it's fairly safe to say that *no psychological function lives in a single part of your brain.* Most of your neurons do more than one thing, psychologically speaking. For example, the parts of your brain most associated with your ability to see, known as the visual cortex (in your occipital lobe), also carry information about hearing and touch. Likewise, some neurons outside of your visual cortex help you to see. Thoughts, emotions, perceptions, imagination, dreams and the rest are better viewed as whole-brain events.

Still, it's possible to carve up a brain by function, but in a different way, based on the information that neurons send and receive. For example, a part of your frontal lobe called the anterior insula routinely plays a role in making your emotions, deciding between options, paying attention to certain things and ignoring others, being aware of yourself, and a host of other mental events. Whatever these neurons are doing, they are always integrating sight, sound, smell, touch, taste, and all the sensations from inside your body, into multisensory summaries that allow your brain to regulate the systems of your body to keep you alive and well.

No matter which way you carve up a brain, it's important to realise that none of these organisations is 'true' in any absolute way. Each organisation is better or worse, depending on the goal you have in mind and what you want to explain. And no organisation alone tells the full story of how your brain, in constant conversation with your body and the world around you, creates your mind.