Marcus Chown
Our incredible shrinking brains

In his 1991 book *Consciousness Explained*, the cognitive scientist Daniel Dennett describes the juvenile sea squirt, which wanders through the sea looking for a rock to cling to. On finding one, it no longer needs its brain. So it . . . eats it.

Dennett's example graphically illustrates the fact that brains are expensive in terms of energy. This is why most creatures on Earth get by without one, and even a creature with a brain like the juvenile sea squirt ditches it once it is no longer useful. "Basically there are two types of animals," says the neuroscientist Rodolfo Llinás. "Animals, and animals that have no brains. They are called plants. They don't need a nervous system because they don't move actively, they don't pull up their roots and run in a forest fire. Anything that moves actively requires a nervous system; otherwise it would come to a quick death."

Humans, of course, not only have a brain but an unusually large one. This is probably related to our switch to a diet with meat – which is more energy-rich than plant matter – and the invention of cooking. Just as writing acts as an external memory, a frying pan is an external stomach. It breaks down the proteins in meat so that they are easier to digest, doing some of the work the gut would do. With less energy needed to service a smaller stomach, there is more energy to support a bigger brain.

Incredibly, the human brain does all of its mega-computing on roughly 20 watts, the power requirement of a very dim light bulb. By comparison, a supercomputer capable of a similar rate of computation requires 200,000 watts. In other words, the brain is 10,000 times more energy-efficient than a supercomputer. Despite this, it is very energy-hungry compared with other tissues. Although the brain accounts for only 2-3 per cent of an adult's mass, it uses about 20 per cent of the body's oxygen.

The huge energy need of the human brain compared with the rest of the body is not surprising given the fact that the brain contains about a hundred billion brain cells – as many as there are stars in our Milky Way galaxy. Each brain cell, or "neurone", may connect to 10,000 others via finger-like extensions called "dendrites". This provides the potential for a thousand trillion connections. And it is in these connections and their relative strengths that information such as memories is stored. Every experience you have every moment of every day changes the connectivity of your brain. In the words of the cognitive scientist Marvin Minsky, "The principal activities of brains are making changes in themselves."

All this rewiring takes energy, which is why thinking makes you tired. "Whenever you read a book or have a conversation, the experience causes physical changes in your brain," says the American science writer George Johnson.

"It's a little frightening to think that every time you walk away from an encounter, your brain has been altered, sometimes permanently." But although the constant rejigging of the brain's neuronal connections takes a lot of energy, humans, unlike juvenile sea squirts, hang on doggedly to their brains.

Or do they? Actually, the human brain has shrunk by about 10 per cent in mass since peaking in size between 15 and 30,000 years ago. One possible reason is that humans once lived in a world of dangerous predators and needed to have their wits about them to avoid being killed. Today, we have effectively domesticated ourselves and many of the tasks of survival – from avoiding immediate death to building shelters to obtaining food – have been outsourced to society. We are smaller than our ancestors too and it is a common characteristic of domestic animals that they are smaller than their wild cousins. It does not mean we are more stupid – brain size is not necessarily an indicator of intelligence – but it may mean that our brains today are wired up differently from, and perhaps more efficiently than, those of our ancestors.

Today, we are only at the beginning of understanding how the human brain works. The brain, not space, is the final frontier. *Star Trek*'s Captain Kirk got it wrong. Some have suggested that it is a logical impossibility for the brain to ever comprehend the brain. "If the human brain were so simple that we could understand it, we would be so simple that we couldn't," said American physicist Emerson Pugh. The get-out, of course, is that the brain is not trying to understand the brain. Many brains are: the combined minds of the international scientific community. As an Italian proverb reminds us: "All the brains are not in one head." •