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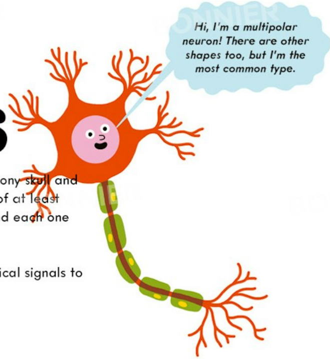
ALL IN THE MIND

A guide to the **AMAZING** brain

COVER NOT FINAL

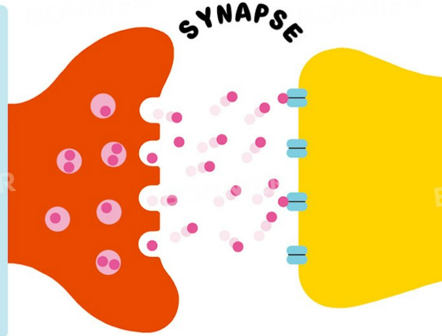
MEET YOUR BRAIN CELLS

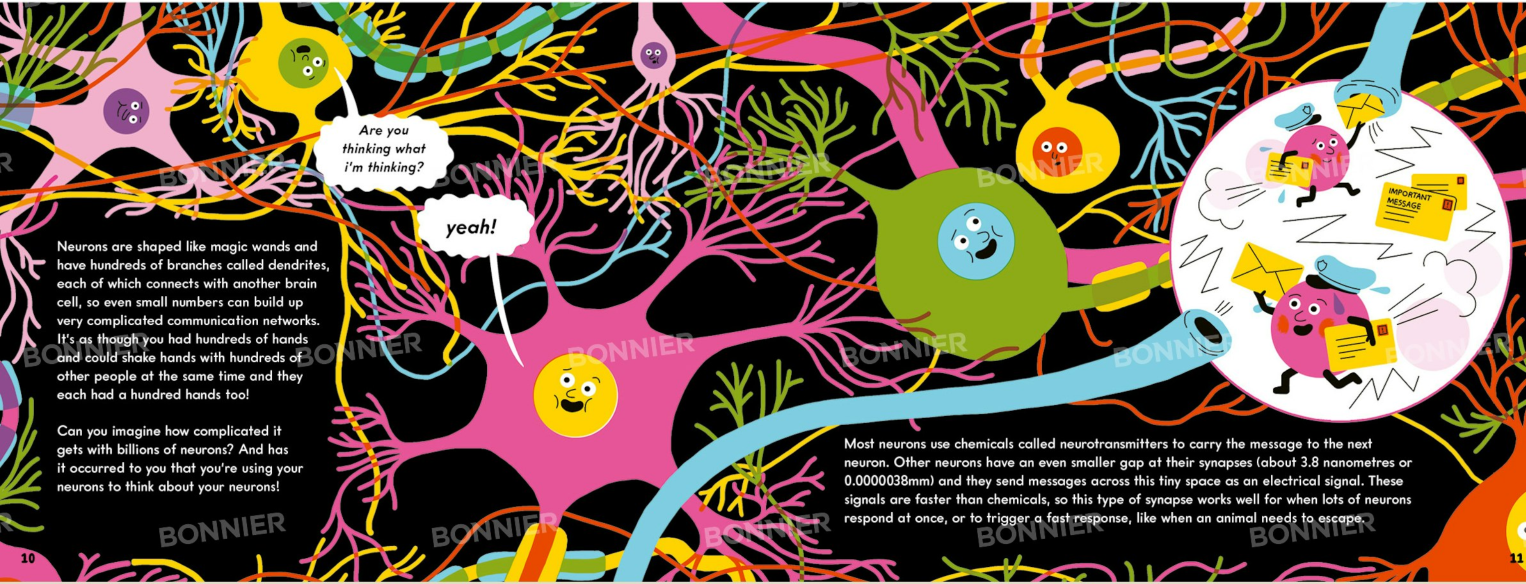


Your brain is a soft, squishy lump of tissue protected by the bony skull and three layers of tough membrane called meninges. It's made of at least 85 billion (that's 85,000,000,000) tiny cells called neurons, and each one communicates with around 100,000 other brain cells. They don't do this by talking, of course, or it would be very noisy inside your head! They use chemicals or tiny electrical signals to 'speak' to each other. Let's meet some neurons . . .

HOW NEURONS TALK TO EACH OTHER

Messages pass through neurons as tiny chemical and electrical signals. They're very fast – in some neurons they can travel over 100m/s. The place where two neurons meet is called a synapse. The neurons don't actually touch each other at a synapse, althoughthe gap between them is very small (about 20 nanometres – that's 0.00002mm).





Neurons are shaped like magic wands and have hundreds of branches called dendrites, each of which connects with another brain cell, so even small numbers can build up very complicated communication networks. It's as though you had hundreds of hands and could shake hands with hundreds of other people at the same time and they each had a hundred hands too!

Can you imagine how complicated it gets with billions of neurons? And has it occurred to you that you're using your neurons to think about your neurons!

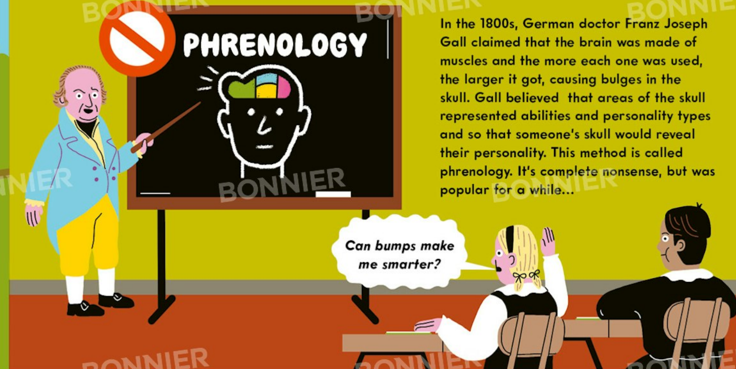
Most neurons use chemicals called neurotransmitters to carry the message to the next neuron. Other neurons have an even smaller gap at their synapses (about 3.8 nanometres or 0.0000038mm) and they send messages across this tiny space as an electrical signal. These signals are faster than chemicals, so this type of synapse works well for when lots of neurons respond at once, or to trigger a fast response, like when an animal needs to escape.

THE HISTORY OF BRAIN STUDIES

It's not easy to study the human brain. It's hard to get at and easy to damage. Early scientific studies of the brain looked at how brain injuries affected people.

Phineas Gage (1823-1860) was an American railroad worker who was injured in an explosion that drove a metre-long iron bar into his cheek, through the front of his brain and out of the top of his head. Amazingly, he survived although he lost an eye. His intelligence and memory seemed unaffected, but friends said the accident changed his personality.

Gage died twelve years after the explosion, possibly due to the long-term effects of his brain injury. But his story helped scientists investigate how the front of the brain might be connected to personality. His skull and the iron bar that caused his injury can still be seen in the Harvard Medical School Museum.

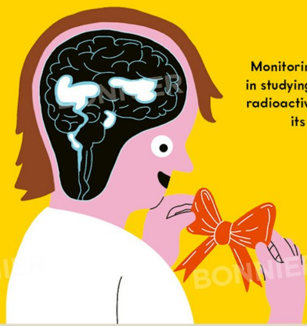


In the 1800s, German doctor Franz Joseph Gall claimed that the brain was made of muscles and the more each one was used, the larger it got, causing bulges in the skull. Gall believed that areas of the skull represented abilities and personality types and so that someone's skull would reveal their personality. This method is called phrenology. It's complete nonsense, but was popular for a while...

MODERN METHODS OF STUDY

Here are a few of the methods scientists use now to study the brain:

Sometimes scientists send a weak electric current through part of the brain to see what effect it has. One area might make someone's leg move suddenly; another might make them see a flash of colour! While this happens, electrical signals in the brain are recorded to give an Electro Encephalogram (EEG). This shows which parts of the brain are connected to certain actions or emotions.



Monitoring changes in brain blood flow are important in studying brain problems like dementia and strokes. A radioactive substance can be injected into the blood so its flow through the brain can be studied.

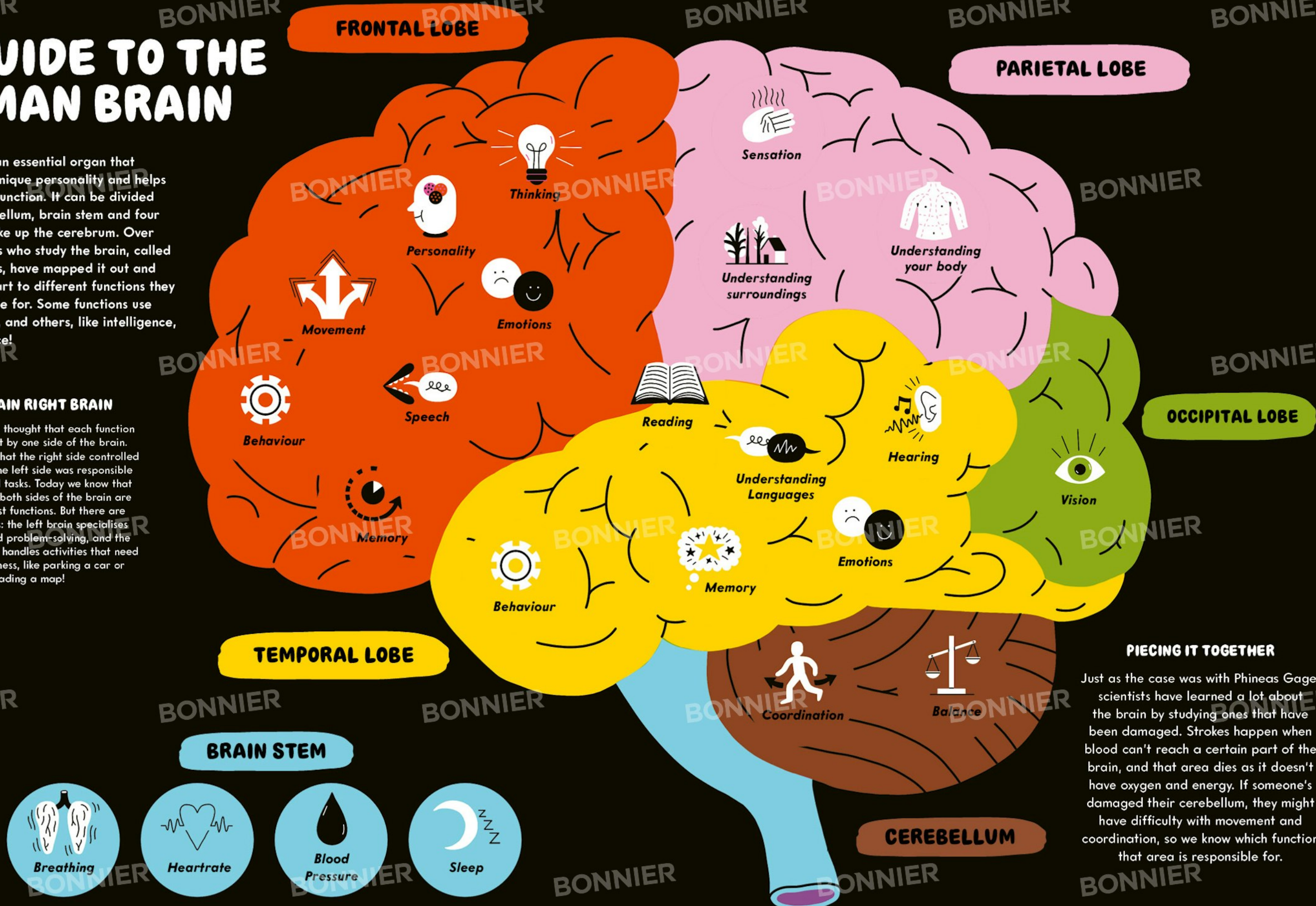
Magnetic Resonance Imaging (MRI) scans use powerful magnets to accurately show which parts of the brain are active when someone carries out a particular task.

A GUIDE TO THE HUMAN BRAIN

Your brain is an essential organ that defines your unique personality and helps your body to function. It can be divided into the cerebellum, brain stem and four lobes that make up the cerebrum. Over time, scientists who study the brain, called neuroscientists, have mapped it out and linked each part to different functions they are responsible for. Some functions use only one area, and others, like intelligence, use lots at once!

LEFT BRAIN RIGHT BRAIN

Originally it was thought that each function was carried out by one side of the brain. People believed that the right side controlled creativity and the left side was responsible for more logical tasks. Today we know that this isn't true – both sides of the brain are involved in most functions. But there are still differences: the left brain specialises in language and problem-solving, and the right brain solely handles activities that need spatial awareness, like parking a car or reading a map!



PIECING IT TOGETHER

Just as the case was with Phineas Gage, scientists have learned a lot about the brain by studying ones that have been damaged. Strokes happen when blood can't reach a certain part of the brain, and that area dies as it doesn't have oxygen and energy. If someone's damaged their cerebellum, they might have difficulty with movement and coordination, so we know which function that area is responsible for.

ARE ALL HUMAN BRAINS THE SAME?

Absolutely not! Yes, all human brains are made from the same types of cells arranged in roughly the same way, but your brain is probably as individual as your fingerprints! The 'wrinkles' on the brain's surface vary from person to person, which means none of us experience the world in the same way.

ECHOLOCATION

Some blind people learn to move through their surroundings by clicking their tongues and listening for echoes, using echolocation, just like bats and dolphins. In experiments, sighted people have learned to do this too. Our brains are incredibly adaptable and can be trained to understand the world in new ways whether we have any sensory limitations or not.

DO YOU NEED ALL YOUR BRAIN?

Some people live relatively ordinary lives even though a large part of their brain is missing. Doctors have discovered people living normally without a cerebellum, or with only one hemisphere, or even with only 10 per cent of a normal brain! This is possible because neurons form new connections to compensate for missing areas.

SUPERSMELLERS

Some people have an incredibly acute sense of smell. Amazingl, some of these 'supersmellers' can sniff out diseases like Parkinson's, a disease of the nervous system. Scientists are now using this information to develop tests to identify the disease faster.

TOUCH

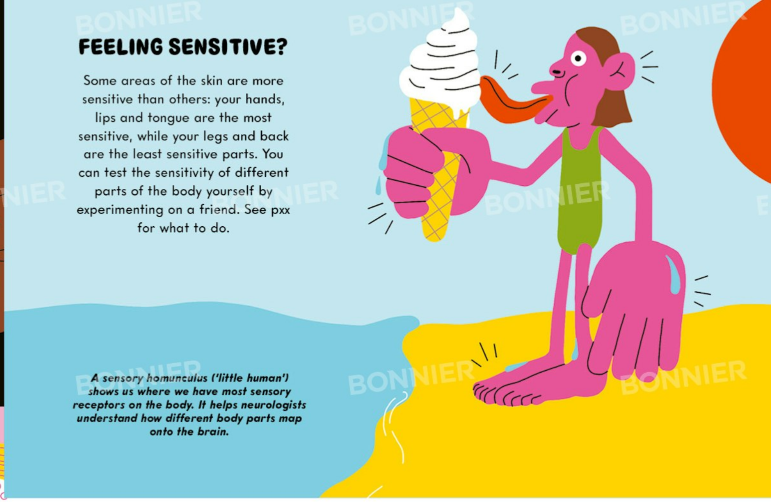
Your sense of touch isn't a single sense at all – it is a network of sensory cells in the skin called the somatosensory system, which detects touch, texture, pressure, temperature, vibration, itching and pain.

EARLY-WARNING SYSTEM

Different types of sensory receptors work together to gather information from your skin. Whenever any of these sensors detect something, a message is sent to your CNS so that your body can respond.

FEELING SENSITIVE?

Some areas of the skin are more sensitive than others: your hands, lips and tongue are the most sensitive, while your legs and back are the least sensitive parts. You can test the sensitivity of different parts of the body yourself by experimenting on a friend. See pxx for what to do.



A sensory homunculus ('little human') shows us where we have most sensory receptors on the body. It helps neurologists understand how different body parts map onto the brain.

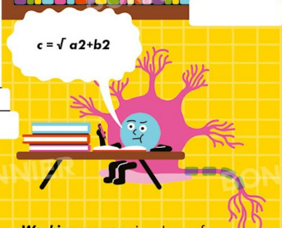
PROPRIOCEPTION


Proprioception is like the opposite of touch. It's your awareness of all the bits of your body. You can touch your nose without looking, and you know exactly how hard to grip an egg so you don't break it. Sensors in your muscles and joints send information about these things to the brain all the time. Life would be exhausting if you really had to think about all these things!

MEMORY

What's your earliest memory? Your most vivid memory? Your favourite memory? Memories are how your brain stores information about what you experience – and this is what allows you to learn.

Short term memory can store a small amount of information for about a minute, for instance the face of someone you've just met, or what happened in the last couple of pages as you read a book. After that, the information either goes into long term memory or is forgotten.



Working memory is a type of short-term memory that allows you to remember information while you work with it, for instance numbers you have to add in your head, or a code you need to put into your phone.

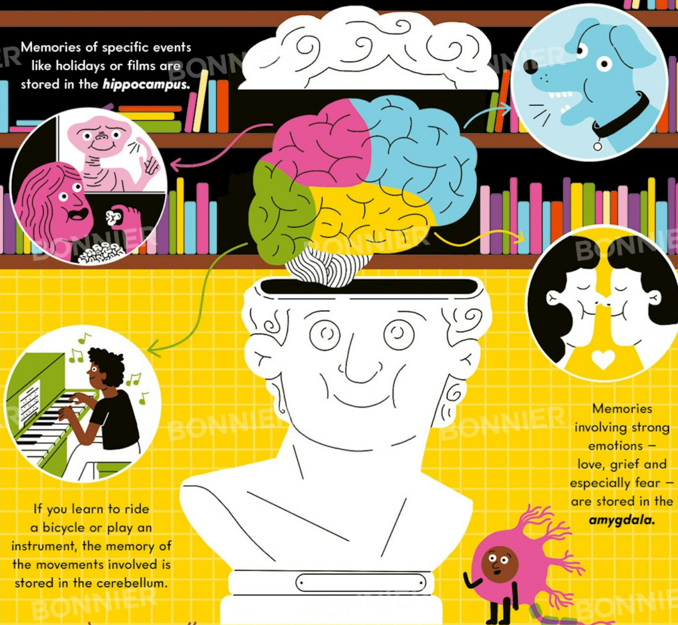
Long term memory can store an unlimited amount of information for many years. When you remember a holiday you had years ago or a grandparent tells you about their childhood, the information has been stored in long term memory.

MEMORY DIRECTORY

Memories are stored in different parts of the brain, depending on what type of memories they are.

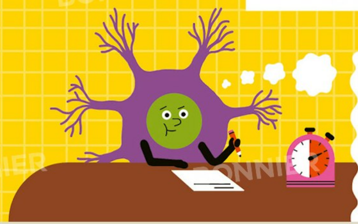
The ***neocortex*** stores memories we could call 'general knowledge' – for instance, ice will make your drink colder, dogs can bark.

Memories of specific events like holidays or films are stored in the ***hippocampus.***



If you learn to ride a bicycle or play an instrument, the memory of the movements involved is stored in the cerebellum.

Memories involving strong emotions – love, grief and especially fear – are stored in the ***amygdala.***

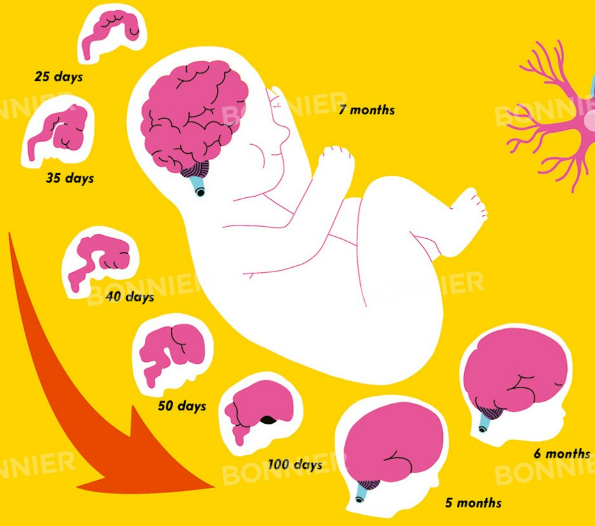


REMEMBER, REMEMBER!

Why not test your memory? Get a piece of paper and something to write with, set a timer for thirty seconds, then turn to pxx and follow the instructions!

HOW YOUR BRAIN DEVELOPS

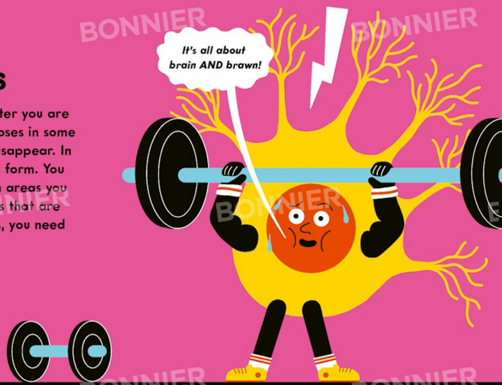
Your brain takes over 20 years to develop fully! It begins to form long before you are born, about two weeks into pregnancy when you are still just a tiny ball of cells. At first, it's a simple tube. The cells on the inside will become your brain and spinal cord and the ones on the outside will become the neurons in the rest of the body.



After about day 40, cells start to divide very quickly – so quickly in fact, that you have more neurons when you are born than you do when you are an adult! Next, the cells shuffle around to get to the right places. They are all there by the sixth month of pregnancy. The cells also change into their final form, growing axons and dendrites and beginning to form synapses.

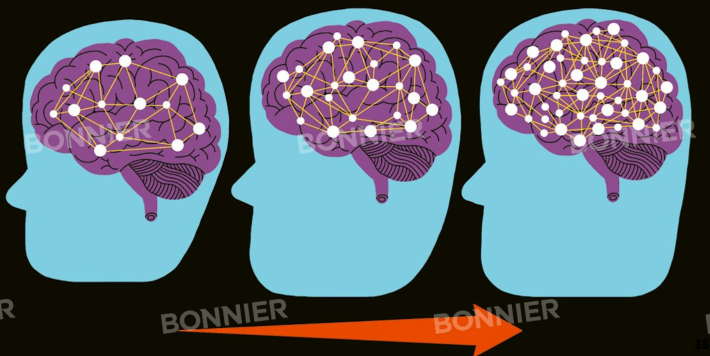
NON-STOP NEURONS

Your brain keeps developing after you are born. There are too many synapses in some parts of the brain, and these disappear. In other parts, lots more synapses form. You develop extra synapses in brain areas you use a lot and lose them in areas that are less used. Just like your muscles, you need to use it or lose it!



THE TEENAGE BRAIN

This process goes on while you are a teenager, and even into your early twenties. Neurologists use to think that brain neurons decreased as you got older, however, more recent research has found that new cells do form in some areas – particularly the ones associated with memory.



LIFE WITHOUT A BRAIN

Even though you definitely couldn't, many living things manage perfectly well without a brain...

MICROBES

Microbes are single-celled organisms – they don't have a single neuron, never mind a brain – but they still manage to move, feed, reproduce and respond to things like light.

PLANTS

Plants have remarkable abilities: shoots grow up and roots grow down; shoots, flowers and leaves turn towards light. Some plants produce natural insecticides to repel insects, and can warn other plants to do the same!

Some plants can move very quickly: the sensitive plant reacts to touch by closing its leaves and flopping them down to protect them. Venus Fly Traps close their leaf blades fast enough to trap insects.

Plants do all this without brains or neurons. Instead, they use chemicals to pass signals from cell to cell. This is form of communication is slower than our nervous system, but most of the time, this suits plants just fine.

SIMPLE ANIMALS

Some animals don't need a brain because they don't make complex decisions. They simply survive and adapt to their environment.

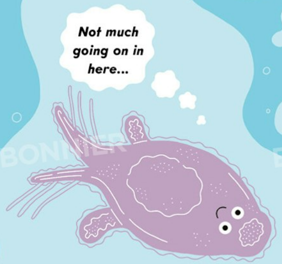
Hydra are tiny freshwater animals. They have the simplest nervous systems: a few thousand neurons, but nothing like a brain.

Starfish have complex nervous systems, but no brains. Their body shape is very different to most other animals – they have no head! Instead, they have a ring of nerve cells around the central disc where their mouth is located, and a nerve running down the centre of each arm.

Sponges are the simplest animals. They don't move, and they eat by filtering tiny particles from the water that flows through them. There's no point in brain cells – they don't need them!

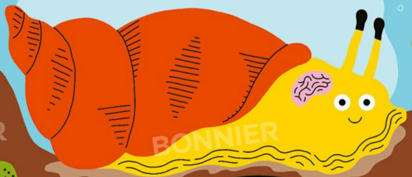
LIFE WITH A SMALL BRAIN

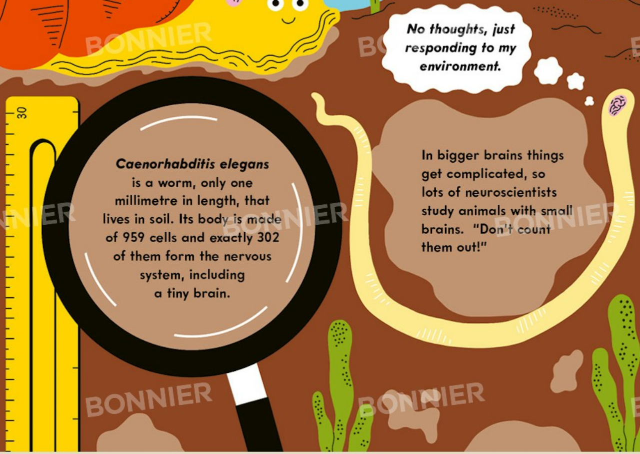
There are animals with brains so small that scientists know how many cells they contain. In these animals, each neuron has a specific function, making their nervous systems highly efficient despite their tiny size.



Rotifers, microscopic freshwater animals, have the smallest brains. An entire rotifer is made of only about 1000 cells and around 200 of these are brain cells.

Pond Snails have about 20,000 brain neurons. That's enough to allow them to learn and remember things.





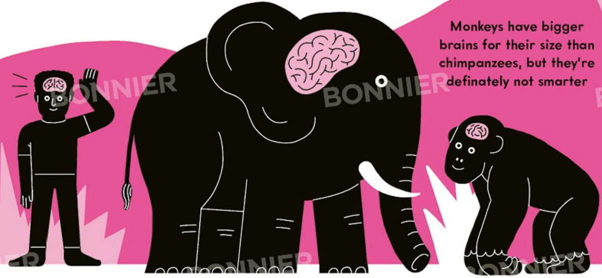
Caenorhabditis elegans is a worm, only one millimetre in length, that lives in soil. Its body is made of 959 cells and exactly 302 of them form the nervous system, including a tiny brain.

In bigger brains things get complicated, so lots of neuroscientists study animals with small brains. "Don't count them out!"

DOES SIZE MATTER?

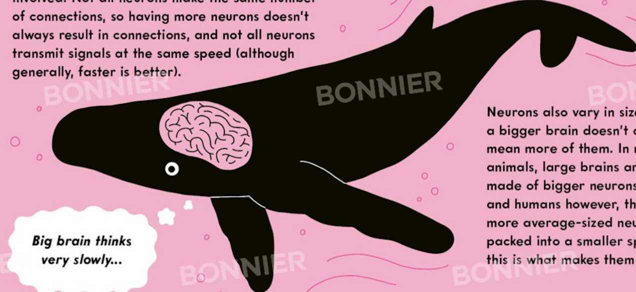
Big animals have larger brains than small animals and the more intelligent an animal species, the larger its brain tends to be, though there are exceptions...

Elephants and whales have bigger brains than humans – does that mean they are cleverer than us?



Monkeys have bigger brains for their size than chimpanzees, but they're definately not smarter

Larger brains don't always lead to greater intelligence – there are lots of other factors involved. Not all neurons make the same number of connections, so having more neurons doesn't always result in connections, and not all neurons transmit signals at the same speed (although generally, faster is better).



Neurons also vary in size, so a bigger brain doesn't always mean more of them. In many big animals, large brains are just made of bigger neurons. In apes and humans however, there are more average-sized neurons packed into a smaller space and this is what makes them smart.

HOW TO LOOK AFTER YOUR BRAIN

Your brain is an incredible organ – and you only have one! It goes without saying that you need to look after it. Here are a few things you can do to keep your brain in tip top condition.

CHALLENGE YOUR BRAIN

If you want to make your muscles strong, you need to use them. It's the same for your brain. Keep your brain working by learning – learn how to dance, play an instrument, or try skateboarding! Do puzzles or play games (see pages 54-60) – anything that makes you think!

STAY ACTIVE

Exercise makes more blood vessels and neurons grow, improves blood flow and helps neurons make more connections. It even increases the speed at which messages travel through neurons.

TALK TO PEOPLE!

Seeing and chatting to other people helps your brain stay healthy as it keeps your brain active. When you spend time with others, you share ideas, laugh and talk about your feelings, all of which can make you feel happier and reduce stress.

REST YOUR BRAIN!

It's always tempting to stay up late... just one more chapter! But sleep is super important for your brain – it needs to rest and recharge. How your brain works when you are asleep is still a mystery! Sleep helps you make lasting memories, think better and feel happier.

FEED YOUR BRAIN!

Foods that help your brain to function well include vegetables, fruit, nuts and grains. Fish, especially oily fish, like sardines and salmon, is particularly good for your brain. The bad news is that processed food like crisps, biscuits, fast food and doughnuts aren't good brain foods. You can enjoy them every once in a while, but focus on having food that is better for your brain.

PROTECT YOUR HEAD

Getting hit on the head can cause serious injuries – remember how soft the brain is – so wear a helmet when cycling, rollerblading, and more. This will reduce the chance of a serious brain injury, but you also need to pay attention and avoid hitting your head if possible.

PUZZLES & BRAIN TEASERS

CONFUSE YOUR BRAIN!

You might fall over when you try this, so find somewhere safe and have something soft to fall onto. Or keep one hand against a wall . . .

1

Stand on your left leg. 'Draw' small clockwise circles in the air with your right leg. Okay, that's fairly easy.

2

Now keep doing that, but at the same time draw small clockwise circles in the air with your right hand. Still pretty easy?

3

Now keep the clockwise circles going with your leg but change the direction of your hand and try to draw anticlockwise circles.

4

Finally, draw clockwise circles with your right leg and anticlockwise circles with your left arm. Easier? Thought so.

What's going on? The right side of your brain controls the left side of your body, and the left side of your brain controls the right side of your body. The left side of your brain gets confused if it has to try to make two parts of the right side of your body move in different directions.

In the final part of the experiment, because each side of your body is controlled by the opposite side of the brain, the two sides of your brain only have to send out one set of instructions each, so they don't get confused.

MEMORY TESTS

Look at the picture of objects below for thirty seconds, then close the book and write down as many as you can remember. No cheating! Don't check your answers yet . . . Wait for 30 minutes without looking at the pictures or the answers you wrote before, then write down the objects you can still remember. Now you can check your answers. The objects you remembered right away were in short term memory. The ones you remembered later on went into your long term memory.

IT'S THE STROOP EFFECT!

Want to see the Stroop effect in action? Don't have a strop – try this out! Time yourself reading out the names of the animals in the pictures. The first group is easy because the word agrees with the picture. The second group takes longer to read because the two sets of information conflict with each other.

ON YOUR MARKS, GET SET, GO...

You need a partner and a 30cm ruler to test your reaction time.

1 Ask your partner to hold the ruler at the 30cm end, with the 0cm end hanging down.

2 Put your thumb and forefinger just either side of the 0cm mark – but don't hold it.

3 Your partner needs to let go of the ruler without telling you. You have to catch it between your thumb and forefinger. Make a note of where on the ruler you caught it.

4 Do this ten times, add up your results and divide by 10 to get an average.

5 Use the table to convert this to your reaction time.

CENTIMETRES FALLEN	REACTION TIME (SECONDS)
0	0 .00
1	0 .04
2	0 .06
3	0.08
4	0.09
5	0.10
6	0.11
7	0.12
8	0.13
9	0.14
10	0.14
11	0.15
12	0.16
13	0.16
14	0.17
15	0.18
16	0.18
17	0.19
18	0.19
19	0.20
20	0.20
21	0.21
22	0.21
23	0.21
24	0.22
25	0.23
26	0.23
27	0.23
28	0.24
29	0.24
30	0.25

THE PUPIL REFLEX

You can try it yourself in a brightly lit room with a mirror. Shut your eyes and cover them with your hands for at least 30 seconds, then look in the mirror as you open them. You should see your pupils get smaller and your iris get bigger.

In a brightly lit room, ask a friend to close their eyes tightly for 30 seconds (with their hands over their eyes to make sure it's dark). When they open their eyes, watch closely and you'll see their pupils quickly shrink in the brighter light.

DON'T GET DIZZY!

Ballet dancers use a technique called spotting to stop getting dizzy and falling over when they turn. You might fall over when you try this, so find somewhere safe and ask permission first.

1 Look at something at eye level like a clock or a tree branch.

2 Slowly turn your body – but keep your head still for as long as possible and keep looking at the same thing from step one.

3 When you can't move your body any further without your head moving, turn it quickly and look at the same spot again.

4 Practise until you get the hang of it, then try spinning, but doing this with your head for every spin.

5 You should find you don't get dizzy, because you only move your head for a very short time, so the liquid in your semi-circular canals doesn't have time to start moving.