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Plan of Hello Brain Exhibition

Key:
- Wall
- Glazed wall
- Column
- Cafe seating area

A  Accessible resources
AT Accessible toilet
E  Entrance/exit
K  Cafe kiosk
N  Knitted neurons
S  Smell socks
T  Toilets
TT Touch table
1  Section 1
2  Section 2
Hello Brain Exhibition Introduction

Breathe. Laugh. Feel.
Talk. Smell. Love.
Forget. Sleep. Taste.
Sing. Change. Trust.
Care. Dance. Hear. See.
Think. Dream.
Connect.

Hello, brain.
You shape my world, my world shapes you.

Handmade neurons
Each of the neurons above you has been knitted, crocheted or simply wrapped and tied by different members of local communities brought together by Neural Knitworks - craft a healthy brain.

Launched in 2014 in Australia, Neural Knitworks is an art-science collaboration that promotes mind and brain health through yarncraft. Over the last decade, Neural Knitworks events around the world have brought hundreds of neuroscientists, health experts and members of the public together in conversation.

Lent by Neural Knitworks founding artist Pat Pillai and UK representative Sophie Weeks

Find out more about Neural Knitworks at https://ow.ly/lX8s50Qtaq7
Section 1

Built on connections
All the thoughts, behaviours and experiences that make you ‘you’ are shaped by countless connections between the cells in your brain. That’s far more connections than there are stars in our galaxy.

How you interact with the world and the people in it is reflected in these connections, and vice versa.

We think, therefore we are.

And we all do it differently.

Let’s take a closer look.

Buff, orange and yellow handmade neurons
These neurons have been made by volunteers from the Crick, community group Hooked on Crochet, the Bristol University Neuroscience Department, Springer Nature, Cancer Research UK, the Camden Working Men’s College and others.

With each stitch and knot, they created new connections between the Crick and its communities. Why not pick up a kit in the gallery café and have a go at making one yourself?

For a full list of contributors, visit https://ow.ly/RZqm50Qtarf
Please touch - Betz cell
These are the largest neurons in your brain. The bulbous bit in the centre can measure as much as a tenth of a millimetre across. That’s big enough to see without a microscope. This cell was knitted by therapeutic radiographer Karen Gurney.

“Recently, I’ve knitted breasts to help start discussions around prosthetics or reconstruction for breast cancer patients who have often experienced emotional and psychological distress and trauma.”

Please touch - Cerebellar granule cell
These neurons are small, but they’re the most common type you have. They make up three-quarters of all the neurons in your brain.

Knitted by Crick research integrity officer Eleanor Adams

Please touch - Astrocyte
Surprise – this star-shaped cell isn’t a neuron! It’s a type of ‘glial’ cell, which are cells that help keep neurons functioning well. As many as half the cells in your brain are glial cells.

Knitted by Crick research integrity officer Eleanor Adams
Please touch - Von Economo neuron
So far, these neurons have only been found in mammal brains. Some scientists think these cells are involved in helping large brains process information more rapidly, generating social emotions like trust and empathy, and learning how to make vocal sounds.

Knitted by Crick research integrity officer Eleanor Adams

Please touch - Double bouquet cell
Does this neuron look like two bunches of flowers? The scientist who first studied – and named – them thought so. Neuroscientist Dawn Davies made this one.

“Frankie MacMillan (who knitted the basket cell) and I contribute to festivals and events through Knit a Neurone. We love talking to people about neuroscience while they create their own neurons!”

Please touch - Purkinje cell
These tree-like super-connectors can connect and interact with up to 200,000 other neurons to help fine-tune your balance and movements. Crick scientist Marg Crawford made this one.

“There’s evidence that Purkinje cells are less common in the brains of autistic people like me, so I decided to knit my own!”
Please touch - Pyramidal neuron

These make up two-thirds of all the neurons in the outer layer of your brain, which is involved in learning, thinking and language. They are ‘excitatory’ neurons, which means they can ‘turn up’ the activity of the neurons they connect to, making them more likely to pass on a signal.

Knitted by Crick craft club member and information services specialist Patti Biggs

Please touch - Basket neuron

The basket-like branches of these neurons give them their name. These cells are ‘inhibitory’. This means they can ‘turn down’ the activity of the neurons they connect to and make them less likely to pass on a signal.

Crocheted by neuroscientist Frankie MacMillan

Please touch - Medium spiny neuron

Each spine on these neurons could potentially connect to another neuron. These spiky neurons make up most of the striatum – an area deep in the centre of the human brain that supports learning and decision-making, and helps control movement.

Knitted by textile artist and Neural Knitworks collaborator Rita Pearce
Please touch - Chandelier neuron

The connections between these neurons and others are one of the types that change the most during our teenage years. Neural Knitworks co-founder Pat Pillai made this one.

“We’re very proud of the decade of Neural Knitworks events held around Australia and overseas, promoting mind and brain health through ‘yarncraft’.”

Hello, neurons

You have 10 times more neurons inside your head than there are people on Earth. These specialised brain cells form highly connected networks that allow you to carry out countless tasks, from detecting the aroma of a ripe apple to remembering a loved one’s face. They come in a vast variety of shapes, each suited to their function.

Meet a typical neuron

Although there are about 10,000 specialised types of neurons in your brain and body, they all have similar features.
Meet a typical neuron

1 Cell body, or ‘soma’
Contains the nucleus, which controls and regulates all the activities of the neuron.

2 Dendrites
Tiny branched structures, which receive incoming signals from other neurons.

3 Axon
A fibre that carries signals away from the soma.

4 Axon terminal
The end of the axon where neurons ‘connect’ with other neurons. They do not physically touch. Instead, the neuron releases a chemical signal that crosses the gap between axon terminal and the next dendrite. The gap is called a ‘synapse’.

![Diagram of a neuron showing cell body, dendrites, axon, and axon terminal.](image-url)
Super-connectors

Purkinje cells are neurons that have extremely branched dendrites, a feature called ‘arborisation’ (‘arbour’ being Latin for ‘tree’). Through these branches, each Purkinje cell can receive signals from up to 200,000 other neurons. They integrate vast amounts of incoming information from your senses and other parts of your brain, passing on signals that help coordinate how you move and balance.

Purkinje cell tagged fluorescent green

Here you can see many dendrite branches and part of the neuron’s single axon terminal emerging from the bottom of the round cell body.

Image: Boris Barbour, Institut de Biologie de l’Ecole Normale Superieure

Please touch this 3D model of a Purkinje cell. Please note the cell is detailed on the front surface only.

Crackle and pop – please listen

When scientists listen in on brain activity, they hear these sounds. Each ‘pop’ is a neuron firing an action potential – the tiny wave of electricity through which your neurons communicate with each other and the rest of your body.

Audio: Blake Porter, Brandeis University
Neuron and on
Just one cubic millimetre of your brain contains around 100,000 neurons, which pass signals back and forth through around 1,000,000,000 connections. That’s a lot of electrochemical chatter. One way to make sense of these signals is to make a map of all the paths they can take – a ‘connectome’.
How do neurons connect?

1. Electrical signals pass along individual neurons

2. At synapses, the tiny gaps between the neurons, the electrical signal transforms into a chemical signal

3. The chemical signal triggers another electrical signal in the neighbouring neuron, and so on

4. Signals can take many pathways, forming complex networks between neurons and the brain
Embroidered connectome (top) and 3D-printed skull

In 1848, a railway worker named Phineas Gage survived an explosion that propelled a metal rod through his head. To better understand how the injury affected Phineas, scientists at the University of California, Los Angeles reconstructed his damaged skull and compiled data from 110 men of about the same age as Phineas to represent his connectome before the accident.

Source: David Morrish, Kingfly Embroidery

Read the original research paper https://ow.ly/MSnR50Qta9A

Connectome (bottom) showing Phineas’s recovery

Although Phineas was walking a few weeks later, friends said he was ‘no longer Gage’. The areas of his brain involved in personality, processing emotions and making decisions had been damaged. This smaller connectome shows the likely reconfigurations that took place in his brain. That he lived and worked for many years after his accident shows how resilient and adaptable our brains can be.

A studio portrait of Phineas Gage taken after his recovery. Gage holds the tamping iron that caused his injury.

Image: Originally from the collection of Jack and Beverly Wilgus, and now in the Warren Anatomical Museum, Harvard Medical School
Modified fMRI scans of mother and child

Functional magnetic resonance imaging (fMRI) can show us the broad effect of millions of neural connections at a time. When you use your brain, more blood flows to your active brain areas. This increase is visualised to represent neural signalling. Neuroscientist Rebecca Saxe created this image by combining different fMRI scans of herself and her baby. The orange patches are brain areas that respond to faces, mirrored in both mother and child in a moment of connection.

Image: Rebecca Saxe, Atsushi Takashi, and Ben Deen, McGovern Institute, MIT

Electroencephalography (EEG) cap

EEG is used to record the electrical activity of millions of neurons at a time. Next to the cap is an example of the information it records. Each squiggly line shows the electrical activity in different areas of the brain, detected by the cap’s electrodes. Doctors use EEG to detect epilepsy, sleep problems, and to monitor brain health in the wake of serious events like traumatic brain injury, stroke and coma.

Source: Waveguard™ original EEG cap, ANT Neuro

Drawing the future

With each line of ink, Santiago Ramón y Cajal sketched out our modern understanding of how the brain is constructed and interconnected. Right here and now, above and below you, hundreds of scientists are
continuing the mission to understand how your neurons hold your thoughts, feelings and sense of self, and govern your every behaviour.

**From Cajal to the Crick**

From the near-monochrome world of Cajal to the colourful modern day – this film shows some of the ingenious and, often, beautiful ways in which Crick scientists image different brains and their contents. From individual neurons to complex networks comprising hundreds or thousands of cells, these visualisations have been created to help research teams better understand how the brain and its connections work.

**The founder of modern neuroscience**

Santiago Ramón y Cajal was born in Spain in 1852. Through detailed anatomical studies and astonishingly accurate sketches, he produced the first clear evidence that our brains are made up of individual neurons. From his observations, Cajal was convinced, but could not prove, that signals flowed along neurons and across synapses in a fixed direction. Imagine his reaction to the imaging technologies available to neuroscientists today!

Image: Cajal Legacy, Spanish National Research Council
Purkinje cell by Cajal

Cajal found this Purkinje cell in a cat’s cerebellum – an area located at the back of the brain which helps control muscle movement and regulate balance. He stained slices of the brain with chemicals to darken and reveal the Purkinje cell’s slender, transparent elements. Then, he drew a detailed ink copy of what he could see with a light microscope.

Image: Cajal Institute, Spanish National Research Council, Madrid

Build-a-brain

Few people get to probe a living brain to learn its secrets. Most scientists rely on images taken through the skull or examining tissue from brains donated for research. Here at the Crick, scientists from different labs are also growing brain tissue in the lab to study how neurons develop, connect and organise themselves.

Neural Circuit Bioengineering and Disease Modelling Lab

Andrea Serio and his team grow neurons in the lab to create mini-models of the networks in our brains. Studying these is revealing how groups of neurons organise themselves and grow together. The models could help explain how our brains work and what changes for people who develop conditions like motor neurone disease and different types of dementias.

Read more about this lab https://ow.ly/Lrx750QtUaA
Short film showing neurons forming connections

This shows individual, green-coloured neurons growing towards red-coloured neurons to form new synaptic connections. Scientists in this lab cut grooves into petri dishes for the neurons to grow along (left) and 3D-print silicon shapes that force neurons to grow in a desired direction (right). In the background of this case, you can see long axons growing away from neuron cell bodies along straight, pre-cut channels.

Credit: Pacharaporn Suklai, PhD student

“We don’t understand something until we can take it apart and start putting it back together. So we're basically turning every component of the brain into ‘Lego pieces’ and assembling them a bit at a time.”

Andrea Serio, research group leader

Neurodegeneration Biology Lab

Sonia Gandhi’s team use cutting-edge technologies to map the brain cell by cell and identify the cells affected by brain disorders like Parkinson’s Disease (PD). They then take skin cells from people with PD and transform the cells into the type of neuron affected by PD. By looking at these cells in high resolution, they’re starting to spot the earliest events that lead to the development of PD.

Read more about this lab https://ow.ly/Qj3R50Qtabm
Human midbrain brain ‘organoid’, painted fluorescent green

A newer aspect of Sonia’s team’s work is creating organoids – ‘mini brains’ – using stem cells generated from people with Parkinson’s Disease. Postdoctoral researcher Gurvir Virdi works with Sonia. He hopes these organoids will help scientists see how the affected neurons and astrocytes behave and interact with each other more clearly in 3D.

“The technologies that we’re using to map the human brain have only become available in the last few years, but they are transforming our understanding of Parkinson’s.”

Sonia Gandhi, senior research group leader

“This research is the foundation of future treatments and provides insights into the mechanisms of disease. I hope that involving people with Parkinson’s like me in research will one day help others.”

Kevin McFarthing, retired scientist and author of the Parkinson’s Hope List

Connecting the dots

When you zoom in down to the scale of neurons, our brain structures don’t look like neat and ordered textbook diagrams. Instead, they are highly complex and interwoven. Like exploring the routes through a maze, Crick scientists from different labs are tracing pathways
from neuron to neuron to figure out how they are organised and work together.

**Applied Biotechnology Lab**

Brain tissue isn’t easy to look at, with its tangled, tightly packed neurons. Postdoctoral researcher Rosa Park and her colleagues are using a technique called expansion microscopy to expand and unfold brain tissue using hydrogel – the same absorbent material as in disposable nappies. The hydrogel expands and spreads neurons out. Then, Rosa uses different fluorescent tags to illuminate individual neurons based on their function, creating a ‘brainbow.’

Read more about this lab [https://ow.ly/J9Ul50QtacB](https://ow.ly/J9Ul50QtacB)

**Hydrogel samples and image of neurons with multicoloured tags**

These identical samples of hydrogel show how much it expands as it goes from dry (left) to wet (right). The images above are what Rosa sees under the microscope before a slice of brain tissue has been expanded with hydrogel (left), and after (right). Before expansion, it’s hard to tell where one cell stops and another begins. After expansion, you can pick out individual neurons and where they specifically connect with each other.

Image: Rosa Park and Johan Winnubst
“We’re asking fundamental questions: What actually is the structure of this thing inside our skulls? What does it look like and how does it all connect?”

Rosa Park, postdoctoral researcher

**Specification and Function of Neural Circuits Lab**

One aspect of PhD student Alex Becalick’s work is to trace the networks of neurons involved in vision. He uses a technique called ‘retrograde labelling’, where he uses a modified rabies virus to hop between neurons in the brain. Instead of causing disease as it spreads, the virus tags networks of connected neurons with unique labels, creating a map of the types of neurons which are connected.

Read more about this lab [https://ow.ly/uBal50Qta8x](https://ow.ly/uBal50Qta8x)

**Neurons in a mouse retina tagged fluorescent red**

The image above shows the neurons in the back of a mouse’s eye. The dots are neuron cell bodies or ‘soma’. The lines are axons – the long threadlike extensions that carry electrical signals to other neurons. You can see many axons joining together to form the optic nerve. This image was created using another form of retrograde labelling that uses a fragment of cholera toxin protein tagged with a red fluorescent dye.
“There are many types of neurons found in the brain. To understand how the circuits that make up our brains work, we ask how these different types of neurons are connected and how this connectivity relates to the function of these neurons.”

Alex Becalick, PhD student

**High-res brain maps**

To study the structure and function of neuron networks, scientists need super-detailed maps of the brain that they can zoom in and out of. Different labs at the Crick are developing new techniques to create anatomical maps of how neurons connect, and linking them to how neurons – and living creatures – behave.

**Fruit fly maggot neurons, artificially coloured and anatomically mapped within its brain**

**Maggot, actual size**

A fruit fly maggot brain contains:

- 3,016 neurons
- 548,000 synapses
For comparison, a human brain contains around:

86,000,000,000 neurons

100,000,000,000,000 to 1,000,000,000,000,000 synapses

**Embroidered connectome of a fruit fly maggot**

A fruit fly maggot’s brain is tiny compared to yours. Yet, at the time of writing, it the most complex brain scientists have mapped in its entirety. The diagram above shows that even with far fewer neurons than we have, a maggot can generate highly complex connection patterns. This allows them to perform, for a maggot, complex social behaviours such as working together to dig for food. Scientists are using the maggot’s newly completed connectome to model how signals travel through its brain.

Source: David Morrish, Kingfly Embroidery; Catmaid

Read the original research paper
https://ow.ly/Y1pq50Qtb4l

**Social Circuits and Connectomics Lab**

At his previous job, Michael Winding helped create the first map of all the neurons and connections in an entire insect brain— that of a fruit fly maggot. With around 3,000 neurons and half a million synapses, mapping this ‘connectome’ was a huge, painstaking task. Here at the Crick, Michael and his team are developing new tools to link brain maps to behaviours. Their goal is to better
understand social behaviours and how social isolation affects brain connections.

Read more about this lab https://ow.ly/fZGm50Qtafx

“The dream is to image brain activity across multiple living animals while they’re interacting with each other and seeing how all of their neurons re at the same time.”

Michael Winding, research group leader

**Sensory Circuits and Neurotechnology Lab**

Scientists Carles Bosch and Yuxin Zhang are mapping the brain’s ‘smell centre’ to work out how our brains process every little whiff. In addition to light microscopes, they use synchrotrons – machines that create light beams billions of times brighter than the sun – to scan brain tissue. By stitching together these ultra-high-resolution scans, they’re building a detailed 3D picture of the many connections and complex pathways involved in the sense of smell.

Read more about this lab https://ow.ly/fHIr50QtagF
What does the sense of smell look like inside the brain?
This animation shows how Carles and Yuxin gather and build their data, identify the relevant parts of the brain tissue, and trace the connections and pathways involved in the brain’s sensational ability to detect different scents.

Credit: Phospho Biomedical Animation

“We combine different techniques to create a map of the brain that we can zoom in and out of. We can look closer and see original images of the tissue, and zoom out and see the whole neuronal networks we’re interested in.”

Carles Bosch, principal laboratory research scientist

“How do the connections between neurons enable humans and animals to sense and interact with the world? We’re trying to make sense of all these intricate connections, condensing them into rules that explain how this happens.”

Yuxin Zhang, PhD student
Section 2

Ever changing, still you
Your remarkable brain keeps pace with a dynamic world, changing from second to second, over your entire lifetime.

Brains have been responding, learning, adapting and evolving for hundreds of millions of years. To try and understand the human brain’s most complex actions, scientists are studying how other animals perform simpler tasks.

What do we have in common?

What makes each of us so unique?

It’s an exciting path ahead to unravel it all.

Smell me!
Here you can smell different scents in the sacks hanging down from the ceiling.

Do you smell like a fruit fly?
Can you detect the individual aromas in the white sacks hanging in front of you? The sacks are stuffed with different scents – from right to left, banana, yeast, orange, mango, menthol (the characteristic component of peppermint), clove, and camphor.
Neural Circuits and Evolution Lab

For fruit flies, smells signal food. They swarm to ripe fruits but some species are repelled by clove and menthol. Our brains and fruit fly brains process smell in incredibly similar ways. Scientists like Lucia Prieto Godino and Sinzi Pop are studying how preferences for different fruits evolved in different species of fruit flies to learn more about how our own brain evolved.

Read more about this lab [https://ow.ly/Hw5V50Qta6l](https://ow.ly/Hw5V50Qta6l)

3D-printed fruit fly brain, magnified x300

Lucia Prieto Godino and her team expose different species of fruit flies to different smells, then map the neuron connections triggered in their brains. By comparing these maps alongside genetic, physical and behavioural differences between related fruit fly species, they can build up a picture of how the fruit fly brain evolved over time. As our brains and fruit fly brains process smell in similar ways, those insights can inform our understanding of the human brain.

Please touch 3D printed adult fruit fly brain magnified 300 times. Made of plastic resin and mounted on a metal rod.

Excited fruit fly brain

In a lab a few floors above you, Crick scientist Sinzi Pop stimulates the olfactory (smell) pathway of fruit flies to see how their brains respond. She does this by puffing fruity odours onto the fly ‘nose’ (the antennae) and
recording neuron activity throughout the brain. The bright areas in these images represent neuron activity in the central part of the fly’s brain before (left) and after (right) receiving the odour puff.

Images: Sinzi Pop

Spin me!

Here you can spin the exhibit to create the visual illusion.

Spin your own illusion
See a swirling cone? If so, that’s because your brain is assuming that the parts of this image that appear to move more slowly are further away than the parts that appear to move faster. In everyday life, this ‘motion parallax’ effect is a form of visual information that helps us work out where we are relative to other objects in space. Crick scientists study how mice combine visual information like this with an understanding of their own movements. All with the goal of better understanding ourselves.

Mice in motion
How do mice see the world? Crick scientists are finding out by watching brains in live action as the mice chase light dots and explore virtual environments on a treadmill, shown in this short film. They record the activity of hundreds or thousands of neurons at once, then map the connections between the neurons involved. By studying the area involved in vision – a brain region that’s
similar in mice and humans – they hope to work out how neurons are connected in our own brains.

Read more about this lab [https://ow.ly/uBal50Qta8x](https://ow.ly/uBal50Qta8x)

**Reality check**

Your brain shapes the way you see the world. But the world can present it with random and ambiguous information. To make decisions efficiently, your brain draws on information coming from your senses while also making assumptions and predictions based on what you already know. As a result, each of us perceives the world slightly differently.

**How can hallucinations reveal how our brains work?**

Crick research group leader Katharina Schmack and her team in the Neural Circuits and Immunity in Psychosis Lab study the biological mechanisms involved in psychosis. In this film, she explains how their work to understand what happens when mice and humans hallucinate could reveal more about how neurons connect and function, as well as new treatments for schizophrenia.

Read more about this lab [https://ow.ly/6fWX50Qtahy](https://ow.ly/6fWX50Qtahy)

**Illusion or hallucination?**

Your brain constantly makes informed guesses about the world around you, using existing knowledge and new
information from your senses. Illusions exploit this by giving you real sensory information that tricks you into experiencing what you expect, rather than what exists.

Hallucinations, on the other hand, occur when you think you can see, smell, touch, hear or taste something that doesn’t exist at all. More extreme hallucinations are sometimes associated with a diagnosis of schizophrenia or dementia. However, we all experience them. At home alone and think you can hear footsteps? Think about bedbugs and suddenly feel an itch?

For information and support about psychosis and other mental health conditions, visit Mind.org.uk https://ow.ly/bZvs50Qtaih

New neurons and connections
All brains constantly reconfigure the connections between their neurons as they adapt to the world – a capability called ‘plasticity’. Every spring, some birds can even grow new ‘song’ neurons. And moles bulk up brain tissue that’s withered over winter. You also generate neurons throughout your life, forming new connections and transforming old ones.

Neural Stem Cell Biology Lab
Stem cells are immature cells that can generate new, more specialised cells. When scientists first found neural stem cells in the mouse brain, it shattered the belief that the brain couldn’t grow more neurons. Francois Guillemot and his team are exploring how these neural stem
cells form new neurons. Understanding this process of ‘neurogenesis’ could help scientists better support people with neurodegenerative conditions like dementia.

Read more about this lab [https://ow.ly/2rut50Qtajc](https://ow.ly/2rut50Qtajc)

**Immature mouse neurons tagged fluorescent green**

This image shows a slice through the hippocampus of a mouse – a part of the brain involved in memory, learning and navigation. Older, established neurons are coloured red. The two bright green shapes are new, immature neurons that have developed from neural stem cells during the mouse’s adulthood.

**New neurons for flirty songbirds**

Press the button to see how many more neurons the song sparrow develops in spring.

Male songbirds like the goldfinch (left), robin (right) and song sparrow (bottom) ramp up their twittering in spring as they try to win mates. In the part of the song sparrow’s brain responsible for producing song, the number of neurons can increase from 150,000 in autumn to 250,000 during the spring breeding season.

Source: David Morrish, Kingfly Embroidery

Read the original research paper [https://ow.ly/sJvj50Qtakl](https://ow.ly/sJvj50Qtakl)
Changing brain volume in the European mole

Press the button to see how the mole brain grows back in spring.

Some animals struggle to find enough food in winter to fuel their energy-hungry brains. The European mole solves this problem by shrinking its brain and regenerating it in spring. Scientists are keen to find out how the brains of these animals expand again, because it may contain clues to treating neurodegenerative conditions such as dementia.

Read the original research paper
https://ow.ly/XUzb50Qtale

Lights out

We spend a third of our lives asleep, but sleep remains deeply mysterious. Although your thoughts and feelings go on hold when the lights go out, your brain remains switched on. As you snooze, connections between your neurons change, take in fresh information, and lay down new memories.

The dreaming zebra finch

Male zebra finches practise singing in their sleep: their vocal cords vibrate and ‘song neuron’ networks activate. One team of scientists believe that sleeping finches also improvise new tunes. This chart shows the activation of vocal muscles during daytime singing (top) and at night
Many patterns are common to both, but can you spot evidence of where the finch improvised its song in its dreams?

Read the original research paper
https://ow.ly/uFZR50Qtall

**What do our neurons do while we sleep?**

Crick postdoctoral fellow Julia Harris and principal laboratory research scientist Mihaly Kollo study how our brains have evolved to process information efficiently. They are particularly interested in the role sleep plays in achieving this. In this film, Julia describes what she and her colleagues in the Sensory Circuits and Neurotechnology Lab are learning about the brain’s surprising activities beyond bedtime.

Read more about this lab https://ow.ly/fHIR50QtagF

**Born with it?**

You grew 250,000 neurons every minute on average in the months before your birth. And yet you were born with so much still to learn. In your first few years, your young neurons formed over a million new neural connections every second. What can you remember from your early childhood?

**Formative memories**

Some experiences stay with us almost all our lives, preserved in the neural connections we form as small children. We asked neuroscientists here at the Crick to
tell us about an early memory that shaped them in some way.

“When I was five, my dad took me to a reptile show where I held snakes and lizards. Since then, I’ve rehomed several reptiles and have tattoos dedicated to them!”

Kelly O’Toole, visiting student

“My grandmother would get a chair for my brother and me to stand on so we could reach the kitchen table. Helping her make gnocchi inspired my love of cooking!”

Marcelo Moglie, postdoctoral fellow

“I learned to play chess at a very young age, and I think that shaped the way I approach problems.”

Karolina Farrell, postdoctoral fellow

“One of my earliest memories is my mom singing a lullaby to stop me feeling scared of the dark. If anxiety hits at night, this bittersweet memory returns to me.”

Basma Husain, postdoctoral fellow

“I used to spend sunny afternoons with my grandmother on her balcony, helping her take care of her plants. That’s where my love for nature started.”

Francesca Montesi, PhD student
“I was bought a soft toy penguin and penguins quickly became my favourite animal. We visited many zoos to see them, which inspired my interest in biology and subsequently neuroscience.”

Tim Goodman, senior lab research scientist

**Short film showing babies in the womb**

With every sight, sound, taste, touch and interaction, a baby’s brain adapts to the world around them – even before it’s born. Being isolated in a hospital incubator can affect how premature baby brains process sound and touch. One study found that playing these babies the sound of their mother’s voice and heartbeat for a few hours each day helped the auditory cortex – the brain area that processes sound – develop and thicken.

Read the original research paper
[https://ow.ly/BE8g50Qtamq](https://ow.ly/BE8g50Qtamq)

**mama brain**

During and after pregnancy, surges of hormones trigger changes that help prepare a pregnant person’s brain for caregiving. As some networks of neurons expand, others shrink, often altering how parents think, feel and experience the world.

Together, ten local mums with tots in tow, artist Zoë Gardner and Crick scientist Bradley Jamieson explored the science and lived experience of this transition to motherhood.
mama brain facilitator, Zoë Gardner
Zoë is an artist, performer, writer and mother of two. She journals and works as a peer supporter, including on NHS maternity wards. Both have helped her own transition to motherhood.

Zoë facilitated our mama brain community project, hosting creative workshops and conversations. In each session, those who attended mapped and shared their transitions to motherhood – the changes they felt in their bodies and brains, the perceived losses and gains.

Zoë journals as @limberdoodle on Instagram and at https://ow.ly/pzNk50Qtan1

mama brain book – a conversation about change in motherhood
Zoë had previously created a handcrafted book about her experience of motherhood, full of doodles, creative prompts and poems she wrote while breastfeeding in the dark. She called it her mother record book. A sequel, mama brain book captures the conversations that unfolded between herself, local mums and Crick scientist Bradley during this community project.

You can find copies of the mama brain book on the coffee tables on the other side of the room behind you.
State-Dependent Neural Processing Lab

Five floors above you, scientists like Bradley are exploring how brain connections are shaped by what happens in the body. They’re particularly interested in instinctive behaviours, including feeding, aggression and parenting.

Hormones from the body and brain trigger instinctive behaviours in the brain both day-to-day and over a lifetime. How do these signals reconfigure entire networks of neurons? What happens to our brains when someone is hungry, sleeping, stressed… or when they’re pregnant?

Read more about this lab [https://ow.ly/NSvV50QtanV](https://ow.ly/NSvV50QtanV)

Neurons associated with caring in the mouse brain

The green, yellow and white areas above mark the location of neurons involved in caring. Postdoctoral Fellow Bradley Jamieson studies changes in these areas to understand why mice do – or sometimes don’t – care for their pups.

How much parenting instinct are mice born with? Which brain connections are crucial and what sparks their activity? Through mama brain, Bradley was able to share his research with human parents who, in turn, shared their insights with him.
Wise ideas
Although we lose neurons as we age, our brains retain their plasticity – the ability to prune old connections and make new ones. By learning more about our brains, researchers hope to develop new treatments for brain diseases that affect millions. You can support your brain as it ages too. Take a card or two to find out how.

Practise mindfulness
A string of recent scientific research suggests that regular meditation practice and mindfulness may boost mental flexibility and focus.

Get active
In older mice, physical activity of moderate intensity is proven to generate the development of new neurons and improve brain function. Could it do the same for humans?

Learn something new
Think about how much you concentrate when learning. In acquiring new skills, we make new connections between our neurons. Better yet, combine learning with physical coordination for a real brain workout.
Eat well
For rats, a diet rich in vitamins and antioxidants and low in fat seems to boost the production of new neurons. Scientists aren’t sure how much diet could affect our brains but acknowledge that eating well boosts energy and improves mood.

Just do it
Take an active step of your own to maintain your brain’s connections and health. Take a blank card and draw or write down one thing you will do to keep your brain plastic and fantastic.

You can view further information here https://ow.ly/yRV550QtapH

Touch Table: Brain models

How did we get brains?
The oldest brain we know of is believed to have appeared 500 million years ago. Scientists debate whether all brains originated from one common ancestor millions of years ago, or if different brains independently evolved many times. What we do know is that once animals developed brains, they reconfigured them in a mind-boggling variety of ways.

Ruairi Roberts is a PhD student in the Neural Circuits and Evolution Lab. Fascinated by the structure of animal brains and how they can change through evolution, he
studies variations in how neurons connect in different species of vinegar fly.

Please touch - Human brain, life-size
3D printed human brain made of plastic resin and mounted on a metal rod.

Hello, brain. So much of what makes you you is contained in these folds. This model is hard, but you’d easily damage a real, squishy human brain with a poke. Not that you’d feel it though—while your brain processes all of your sensations, it doesn’t have any sensory neurons of its own

Please touch - Mouse brain, magnified 8 times
3D printed mouse brain made of plastic resin and mounted on a metal rod.

Despite what it looks like, this brain is the most similar to your own brain compared to the other brains on this table. Mice rely on smell far more than we do, so they have a quite large olfactory bulb – the part of the brain that processes smells. Can you guess which bit that is?

Please touch - Capybara brain, life-size
3D printed capybara brain made of plastic resin and mounted on a metal rod.
The world’s biggest rodent has deep, wrinkled folds in the outer cortex of its brain, like ours. You may have heard that the more wrinkled the brain, the more complex the creature’s abilities, but whether this is true is unclear. Larger animals tend to have more wrinkly brains than smaller animals, but ‘intelligence’ remains a difficult quality to define let alone study.

Please touch - Zebrafish brain, magnified 30 times

3D printed zebrafish brain made of plastic resin and mounted on a metal rod.

At around 4mm long, a zebrafish brain may be much smaller than yours but it still has all the main structures found in your brain. That’s not surprising as you share common ancestors. Up to 84% of genes associated with human diseases have a counterpart in the zebrafish genome. Zebrafish are increasingly being used to study neurodegenerative conditions such as Alzheimer’s disease.

Please touch - Goldfish brain, magnified 4.5 times

3D printed Goldfish brain made of plastic resin and mounted on a metal rod. Please note there is a smooth plastic support underneath a thinner section of the 3D model, this is not part of the brain.

Contrary to popular belief, goldfish can retain information for months rather than seconds. Here’s something else
you may have in common–taste is an important sense for them. Up to a fifth of their neurons are dedicated to this. Sucking up and spitting out sediment in their tanks isn’t a random act–they’re carefully sorting food from gravel.

Please touch - Crow brain, life-size
3D printed crow brain made of plastic resin and mounted on a metal rod.

Crows are cognitive high-fliers, able to create and use tools, understand numbers, and make complex decisions. Birds seem to have developed a very different strategy to squeeze more cells into their skulls. Their small, smooth brains are more densely packed with neurons than those of many mammals.

Please touch - Nile crocodile brain, life-size
3D printed Nile crocodile brain made of plastic resin and mounted on a metal rod. Please note there is a smooth plastic support underneath a thinner section of the 3D model, this is not part of the brain.

Crocodile brains are relatively small for their bodies, but they’re highly specialised. Hundreds of pressure sensors on their faces tell their brains where prey may be splashing about. Their prominent olfactory bulbs–the round bits on the ends of these ‘stalks’–help these scavengers pinpoint the smell of a dead animal up to four miles away.
Please touch - Wolf and English bulldog brains, life-size

3D printed wolf and English bulldog brains made of plastic resin and mounted on a metal rod.

The English bulldog was selectively bred for its powerful underbite to allow it to grip a bull’s nose or neck. This didn’t just alter the shape of its skull but what’s inside as well. Both the English bulldog’s skull and brain are shorter and flatter than those of its long-extinct wolf ancestors or wild relatives.