**Mapping the Brain's Secrets: A Cubic Millimetre Revealed**

**Zareena, Mookayi and Mari**

Mookayi hurried inside Zareena’s house not even bothering to park her cycle properly. “Zar, just now Mari called. It seems she and her mother have come back home. Let’s go. Been almost 2 months since we saw them”.

Zar who was immersed in her book, did not look up but said, “Just hold on. I will finish this and come. I am almost at the end”.

Mooks walked away angrily to the kitchen to get something to eat. After some minutes Zar came over telling “Hey, don’t be bugged. I also want to meet Mari to find out what interesting things they saw and learnt during their US trip.”

Mooks who was munching on some peanuts and looking outside did not turn. “That is why I came as soon as Mari messaged that she is home. You did not even see the message or reply to my message saying let’s meet at Mari’s house. I also tried calling you and you did not pick up the phone”

Zar hugged Mooks. “Don’t pout. I was trying to finish the book. I did not go near the phone as I get distracted. Come let’s go now. Pleeease ...”.

Mooks flashed a bright smile and they both got on their cycles to visit Mari.

Reaching Mari’s house they found her in the kitchen with her mother Usha sitting and having coffee. After the greetings and hugging were over, Mooks and Zar said, “Tell us the news. Give us the juicy details”.

Mari exclaimed, “Oh, it was incredible, Mooks and Zar! We visited **Google** in San Francisco and then **Harvard University** in Cambridge. We met some amazing scientists working on the brain *connectome*.”

Mooks asked confused “Brain connectome? What’s that?”

Usha clarified, “It’s a detailed map of neural connections in the brain. Think of it as a comprehensive wiring diagram that shows how every neuron is connected to every other neuron.”

**BOX What is a neuron?**

Neurons, also known as nerve cells, send and receive signals from your brain. While neurons have a lot in common with other types of cells, they’re structurally and functionally unique.

Specialized projections called *axons* allow neurons to transmit electrical and chemical signals to other cells. Neurons can also receive these signals via rootlike extensions known as *dendrites*. Neurons are responsible for carrying information throughout the human body. This allows you to do everything from breathing to talking, eating, walking, and thinking. Neurons communicate with other cells via *synapses*, which are specialized connections that commonly use tiny amounts of chemical *neurotransmitters* to pass the electric signal from the pre-synaptic neuron to the target cell through the synaptic gap. A 2009 study estimated that the human brain houses about 86 billion neurons!

**END OF BOX**

Zar was impressed. “Wow, that sounds complicated! Who are the scientists you met?”

Mari offering the coffee she had made for Zar and Mooks said, “We met **Viren Jain** at Google and **Jeff Lichtman** at Harvard. They’re leading teams that are pioneering new ways to study the brain’s connectivity”.

Mooks always liked the coffee at Mari’s house. She smiled and said, “This coffee is so good always. Your trip must have been great. From your voice, it looks like you wanted to join them and start working right away with them. What kind of work are they doing exactly?”

Usha pitched in. “Their teams have been working on reconstructing a small 1 cubic millimeter fragment of the brain from the human cerebral cortex at nano-scale resolution.” Looking at the puzzled faces, she said, “Let me make it simpler. We know that atoms are about Angstrom in size, which is 10-10 m. Ten times that, or 10-9 m, is called a nanometer. So studies of nanometer-sized objects are called *nanoscale* studies.

Now, you also know that many organs in humans such as brain and kidney have an outer and inner part, called *medulla* and *cortex*. Also, the brain is divided into many portions of which the cerebrum is the front part; see the picture.”

Zar remembered and quoted from memory, “The cerebral cortex, also called gray matter, is our brain’s outermost layer of nerve cell tissue. It has a wrinkled appearance from its many folds and grooves. It plays a key role in memory, thinking, learning, reasoning, and problem-solving, emotions, consciousness and functions related to our senses”.

“Yes”, said Usha. “They sliced the small piece of brain into around 5,000 slices. Each was just 34 nanometers thick!”

Zar eating the bajji asked, “How do they get such detailed images?”

Usha came over saying, “They use *high-throughput serial section electron microscopy*. Remember you guys wrote in ***Jantar Mantar*** once about the 2017 Nobel Prize in Chemistry for seeing molecules using electron microscopy? Here they took the thousands of very thin slices of brain tissue and then imaged them at an extremely high resolution. See the picture showing the positions of the neurons in a small portion of the brain cortex. The neurons are coloured according to size.”

Mari brought over some bajji that Usha had been making. “So they are imaging the brain tissue in such fine detail that they can see individual synapses and neurons! The picture shows a single neuron in white with about 5,600 axons (in blue) that connect to it. The synapses that make these connections are shown in green”.

Mooks reached out for another bajji. “That must generate a lot of data!”

Usha moved the plate to her saying, “Of course. The data-set they’ve created is enormous – about 1.4 Petabytes. To give you an idea, that’s roughly equivalent to 700,000 hours of high-definition video!”

Zar said “What’s a Petabyte? Is it related to Gb or gigabyte we know?”

Mooks quickly answered looking smug “Yes, I learnt about it. 1024 *Gigabytes* is 1 *Terabyte* or Tb, and 1024 Tb is 1 *Petabyte* or Pb. Correct?” and she looked anxiously at Usha who smiled and nodded.

 Zar continued “And what did they learn from all that data?”

 Mari went on talking while taking away the empty plates. “They analyzed it to map out the neural circuits. This one-millionth of a whole brain was found to contain roughly 57,000 cells and 150 million synapses. They’ve even discovered a new class of neurons which were triangular in shape. They found new patterns of connections between neurons, as well as cells that wrap around themselves to form knots, and pairs of neurons that are almost mirror images of each other ”.

 Mooks was surprised. “A new class of neurons? That’s amazing! What else did they find?”

 Usha said, “We’ve got ice cream. Not from the US! But from our nearby store. I will get some”. And she continued, “They found some very powerful and rare multi-synaptic connections between neurons. These connections could help us understand how the brain processes information and could provide insights into brain disorders”.

Zar, ever the practical one, piped in. “This sounds like it could lead to some major breakthroughs in neuroscience”.

Mari cleaning the plates said from the sink. “Definitely. By understanding the brain’s wiring in such detail, we can learn more about how it functions normally and what goes wrong in conditions like *epilepsy*, which is actually how they got the brain sample – from a patient undergoing surgery for epilepsy”.

**One-line BOX**

**Epilepsy is a chronic brain disorder in which groups of nerve cells, or neurons, in the brain sometimes send the wrong signals and cause seizures**.

**END OF BOX**

Mooks was amazed. “It’s incredible how they can turn such a challenging situation into an opportunity for research.”

 Usha bringing four cups of ice cream said, “The nice thing is that they have made all their data freely available on-line. The map they have made by stitching together the images is so large that most of it has yet to be manually checked, and it could still contain errors created by the process of stitching so many images together. Hundreds of cells have been what they call proof-read, but that’s obviously a few per cent of the 50,000 cells in there.”

Mari handing out the ice creams said, “The scientist Jain from Google whose team did the reconstruction and proof-reading says he hopes that others will help to proof-read those parts of the map they are interested in. There is a notice outside their lab saying ‘Proof-readers wanted’. When we went the first time I thought it was a joke. The team also plans to produce similar maps of brain samples from other people.”

Usha went on, “By sharing freely all of their data and tools on-line, they hope other scientists can build on their work and make new discoveries”.

Zar enjoying the ice cream asked, “So, what’s next for this research?”

Mari looking at her empty cup of ice cream went on. “Their goal is to continue expanding this connectome to include different regions of the brain and eventually to map an entire human brain. It’s a huge huge task, but a map of the entire brain is they say unlikely in the next few decades. They are certain the potential benefits are going to be tremendous.”

Mooks collecting all the empty cups and putting them into the dustbin sighed. “This is all so fascinating. Only wish we can be a part of it.”

Usha smiled. “Not now. Later. I am sure, knowing you three, you will end up getting involved in this area of research. For now, why don’t you eat more ice cream, and write this as an article for our ***Jantar Mantar***!”

***References:***

1. **Science**, Vol 384, Issue 6696, 2024, https://doi.org/10.1126/science.adk4858

2. **Nature News**, Vol 629 pages739-740, 2024, https://doi.org/10.1038/d41586-024-01387-9