Santiago Ramón y Cajal

The Rebel Kid Who Drew the Brain

Author: Nick Quark · Recommended age: 7–12 · 13 chapters

Name: _____ Date: _____

1. Before you read

1. What do you like doing most when nobody is telling you what to do? Do you think it could be useful for a job one day?
2. Put your hand on your head. What do you imagine is inside? Draw it before you read the book.
3. Do you think you have to be a genius to discover something important? Write down your answer and come back to it at the end.

2. Comprehension questions

*Keep the book in front of you: look things up, reread, and answer in your own words. The labels tell you what kind of question it is: **fact** (it's written in the book), **why** (you have to explain a cause), and **opinion** (there's no single right answer).*

Chapters 1 and 2 · The boy who drew and the eclipse

1. Why did Justo, Santiago's father, get angry when he caught him drawing? [WHY]
2. What impressed Santiago most about the 1860 eclipse? [FACT]
3. The book corrects two mistakes that people always make when they tell the eclipse story. What are they? [FACT]

Chapters 3 and 4 · The cannon and the shoemaker

4. What did Santiago build at eleven, what did he do with it, and how was he punished? [FACT]
5. Why did his father put him to work as a shoemaker's apprentice? [WHY]
6. His father tried to cure his drawing habit with punishments. Do you think he was right? What would you have done? [OPINION]

Chapters 5 and 6 · The bones and the gym

7. Why did his father change his mind about drawing in the summer of 1868? [WHY]
8. What did Santiago do so the class bully would stop picking on him, and what did he learn from it? [FACT]

Chapters 7 and 8 · Cuba and the microscope in the kitchen

9. In Cuba, what killed more soldiers, and which diseases did Cajal himself catch? [FACT]
10. What did he buy with his savings from Cuba, and what did the provincial government of Zaragoza give him after the cholera epidemic? [FACT]

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Chapters 9 and 10 · The black reaction and his greatest year

11. What was magical about Golgi's black reaction? FACT

12. Why did Cajal start using the brains of embryos and newborn animals? WHY

13. What did almost all scientists believe the nervous system was, and what did Cajal discover? FACT

14. What did Cajal do in Berlin in 1889 to make the scientists believe him, and who came over to look? FACT

Chapters 11 to 13 · Butterflies of the soul, the Nobel, and the school

15. According to the law of dynamic polarization, which way does a message travel through a neuron? FACT

16. Why was it awkward that the 1906 Nobel Prize was shared with Golgi? WHY

17. In the 1950s, what made it possible to prove that Cajal was right? FACT

18. Cajal said anyone can become "the sculptor of their own brain." What would you like to learn through practice? OPINION

3. Timeline

Every date comes from the book. There are three blanks, marked ✎: find the year and write it in.

1852	He is born in Petilla de Aragón on May 1.
1860	He watches the solar eclipse of July 18 in Valpalmas.
✎ _____	At eleven: the Ayerbe cannon and his days in the village jail.
1873	He finishes his medical degree in Zaragoza.
1874	He sails to Cuba as an army medical captain.
1887	He sees the black reaction at Luis Simarro's home and moves to Barcelona.
✎ _____	His "greatest year": he shows that neurons are independent pieces.
1889	He shows his slides in Berlin. Kölliker is amazed.
✎ _____	Nobel Prize in Medicine, shared with Camillo Golgi.
1934	He dies in Madrid on October 17.

4. Science vocabulary

Neuron
The cell of the nervous system, specialized in receiving and sending messages. Cajal showed that each one is an independent piece.

Dendrites
The short branches of a neuron, like the crown of a tree. Messages reach the neuron through them.

Axon
The long extension of a neuron, like a cable, through which the message goes out. Some are about three feet long.

Synapse
The place where one neuron passes its message to another, almost touching but not joined.

Black reaction
The silver staining method invented by Golgi, which turns a few whole neurons black, with all their branches.

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Histology
The science that studies the body's tissues with a microscope. Cajal was professor of histology in Madrid.

Reticular theory
The old idea that the nervous system was one continuous net, with all its fibers joined, like a fishing net.

Plasticity
The brain's ability to change its connections when we learn or practice. Cajal sensed it in 1894.

5. Try it at home: the ruler test

Between your eyes seeing something and your hand moving, the message has to travel through lots of neurons. You're going to measure how long it takes, and see whether it gets better with practice.

You need

- A 12-inch ruler.
- A friend or a grown-up.
- Paper and pencil to write things down.

Steps

1. Your friend holds the ruler by the top end, hanging straight down.
2. You hold your thumb and index finger open at the zero mark, without touching the ruler.
3. Your friend lets go without warning and you catch it as fast as you can. Write down the number where you caught it.
4. Repeat ten times and write down every result. If you can, do it again another day.

What to look for

The lower the number, the faster you reacted. Are your last tries better than your first? Is it better with the hand you write with or with the other one?

What it has to do with the story

The message travels from your eye to your brain and from your brain to your hand, passing from neuron to neuron across the synapses Cajal predicted. And if you get better with practice, you're seeing what he imagined in 1894: when you practice, your brain changes its connections.

Safety: no risks. Just don't drop the ruler near anyone's face.

6. Talk or write about it

Class discussion

Golgi invented the method, and Cajal used it to discover the opposite of what Golgi believed. Was it fair for them to share the Nobel Prize? Find arguments for both sides.

Writing (half a page)

Write what Santiago might have scribbled in a secret diary on his first night in the Ayerbe jail.

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Answers for grown-ups

*The **opinion** questions (6 and 18) have no set answer: any well-reasoned response is fine. For the **why** questions we give the explanation the book offers, as a guide.*

Comprehension questions

1. Because to him drawing was a waste of time, a distraction that pulled his son away from serious things: he wanted him to be a doctor.
2. That the scientists had predicted it: months in advance they had worked out the day, the hour, and even the minutes.
3. That it didn't happen in Ayerbe but in Valpalmas, and that it wasn't total: the Moon covered 99.96 percent of the Sun.
4. A wooden cannon reinforced with wire and string. He blew a huge hole in the gate of a neighbor's vegetable garden, and the mayor locked him in the village jail for three or four days.
5. So he would learn how hard life is without an education, and to root out his drawing habit once and for all.
6. *Opinion: no set answer.*
7. Because he saw Santiago's drawings of the cemetery bones, precise and beautiful, and understood that drawing wasn't a whim but a tool for science.
8. He trained for months by the river and in a gym until he was the strongest there. He learned that the body changes with training, and later he would wonder whether the brain did the same.
9. More soldiers died from disease than from bullets. He caught malaria and then dysentery.
10. His first microscope. After the cholera epidemic, Zaragoza gave him a Zeiss microscope.
11. The silver stain stuck to only a few cells out of thousands and turned them completely black, with all their branches, against a background as yellow as gold.
12. Because in an adult brain the cells are too crowded and tangled; in young ones they were smaller, less crowded, and the stain worked better.
13. That it was one continuous net, with all the cells joined together (the reticular theory). Cajal discovered they are independent pieces that communicate by touching without joining.
14. He set up his microscope and slides in a corner of the hall and waited for someone to look. Albert von Kölliker came over.
15. It comes in through the dendrites, passes through the cell body, and goes out through the axon to the next neuron, always in the same direction.
16. Because Golgi still defended the continuous net that Cajal had shown to be false, and spent most of his Nobel lecture attacking the neuron doctrine.
17. The electron microscope, far more powerful, which showed the gap between one neuron and the next.
18. *Opinion: no set answer.*

Timeline blanks

- **1863** — the Ayerbe cannon.
- **1888** — his "greatest year."
- **1906** — the Nobel Prize, shared with Golgi.

Before you read and Talk or write about it

No set answers: these are for sparking ideas and conversation. Question 3 of "Before you read" is answered in "Cajal's Advice," at the end of the book.

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