Google It

A HISTORY *of* GOOGLE

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ANNA CROWLEY REDDING

To Crowley and Quinn,
may you always shoot for the moon

PART 1

Frenemies + Homework + Legos = Google?

A Cold, Hard, Google-less World

N EED TO KNOW HOW many stacked pennies it would take to reach the moon? Want to know about the latest visual effects technology used to make *Star Wars*? Need to know if George Washington really had dentures made out of wood?

FYI:

- It would take a stack of 240 billion pennies to reach the moon!

- *Star Wars* special effects—Check out this cool link for a peek at how the latest computer graphics (CG) were used to pull off the stunning visuals. https://www.youtube.com/watch?v=obwG9k6x2us

- Was George Washington's wooden smile made from wooden teeth? NO. His *false* teeth were actually made of bone, ivory, and sometimes other humans' teeth.

Imagine you can't google the answers because—well, Google hasn't been invented yet.

You have two choices. You can sit there on your couch, swallow your curiosity like a bitter pill, and live with *not* knowing.

Or you can get your parents to drive you to the library. Fingers crossed, the answers you need are somewhere in the pages of a book that's somewhere on their bookshelves.

But wait a minute. What if your parents don't know how to get to the library? You'll have to consult a paper map.

> **WARNING!** Unless you are an origami dynamo, once you unfold a map, it might never be refolded correctly. Never. Don't even try.

Still can't find it?

It may come down to this: You have to use a paper phone book to look up the library's phone number. Then, pick up your home phone (the kind that's wired to a wall), wait for a real, live human being to answer, and then *ask* for directions. Yikes!

It's hard to believe, but that was life without Google. Getting information was difficult and took a lot of work.

Horrified? The two guys who thought up Google were just as freaked out as you are. This was the world they grew up in, back in the 1970s and 1980s. And even as kids, Google co-founders Larry Page and Sergey Brin knew they wanted to change the world.

> When Larry and Sergey were born in 1973, technology was in a very different place than it is today. In most homes, telephones were attached to walls and could only be used to make phone calls. No texts, no news, no maps—just phone calls. Hope was coming. That year, the first-ever cell phone call was made. But these cell phones were huge, like talking into a brick. Plus, the battery life was around twenty minutes. And then there was the price tag: $3,995! In today's dollars? That would set you back more than $22,000.

Oh, and about your TV. If you needed to change the channel, you had to get up and physically turn a dial on your TV set, unless you were one of the lucky ones who had a pricey remote control!

Computers had been something used mostly by scientists, engineers, and mathematicians in research and academic settings. They were physically huge and could take up an entire desk or even a whole room. But *this* last thing was about to change—just in time to inspire Larry's and Sergey's love of technology.

But it wouldn't be easy. Larry and Sergey were born on opposites sides of the planet. And when their paths finally crossed, they didn't even like each other.

It's a wonder Google ever happened at all.

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Frenemies: Fight@1stSight

When Larry and Sergey met during the summer of 1995, they *should* have been the best of friends. After all, they both loved computers, math, engineering, science, and technology. They had both attended Montessori schools and grown up in families steeped in STEM. That's a lot in common.

BFFs at first sight, right? Nope. Not even close.

When they met for the very first time, Larry and Sergey couldn't stand each other! Twenty-two-year-old Larry was supposed to be enjoying a welcome tour of San Francisco for new students checking out nearby Stanford University. Already accepted to Stanford, Larry was giving the university a thorough look-see before deciding if he wanted to study there—though secretly he couldn't believe Stanford wanted him!

Spanish colonists founded San Francisco in 1776. The Gold Rush of 1849 made San Francisco the largest city on the West Coast. Today, the San Francisco Bay Area is home to 8.7 million people, making it the fifth-largest metro area in America.

Enter twenty-one-year-old Sergey. He was the tour guide. Who better to lead the tour? As a second-year graduate student, Sergey was known for zipping around Stanford's hallways on Rollerblades. He was not only fun, he was smart, too. Sergey had already aced his required courses and now devoted a serious

chunk of time to advanced swimming, trapeze lessons, and Ulti-mate Frisbee. (Oh! And some elective courses. He did fit *some* study into his free time.)

But as Larry and Sergey trudged up one hill and down another, this duo filled the streets of San Francisco with their bickering banter. They argued about anything and everything . . . needling, poking, prodding, questioning, interrupting, and talking down to each other. Their first meeting was a disaster.

The only thing the two agreed on was their opinion of the other. In a word? *Obnoxious*.

Aerial view of Stanford University. (Photo by Jrissman.)

The sprawling 8,000-acre Stanford University campus was designed by Frederick Law Olmsted (designer of New York City's famous Central Park). Sitting in the heart of Silicon Valley, Stanford has long been an incubator for creativity and innovation. Companies including Hewlett-Packard, Yahoo!, Cisco, Intuit, and SunMicrosystems can trace their origins to Stanford.

But the same chemistry that sparked the nonstop squabbling also acted like a magnet. By the time school started in the fall of 1995, Larry and Sergey had discovered that they actually had a lot in common, from their science-filled childhoods to their passion

for technology and engineering, not to mention their undeniable knack for spirited debate. Both Larry and Sergey were confident in exploring new ideas and taking risks. They were also both obsessed with efficiency and improving the way things worked.

And in just a few months, they would team up on a school assignment that would change their lives—and ours, too.

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SERGEY BRIN

NAME: Sergey Mikhaylovich Brin

DATE OF BIRTH: August 21, 1973

PLACE: Moscow, Russia

FIRST COMPUTER: Age 9, Commodore 64

Commodore 64. (Photo by Evan Amos.)

Sure, by today's standards, the Commodore 64 isn't much to look at, but this remains one of the most popular computers ever sold. Because of the quality of the audio and graphics, it was great for gaming. The Commodore 64 sold for $595 in 1982.

FAMILY: Sergey Brin was born into a family of intellectuals. His great-grandmother? A microbiologist. His grandfather? A math professor. Both of his parents were brilliant mathematicians.

They were also very brave. Faced with anti-Semitism and discrimination in their home country of Russia, Sergey's parents made the difficult choice to leave everything behind and start a new life in America. Sergey was only six years old.

Immigrating to the United States during the 1970s was no simple matter. Like many immigrants, the Brin family had to leave most of their belongings behind. But an American-based agency devoted to immigrants helped Sergey's family. The Hebrew Immigrant Aid Society helped the Brins navigate the paperwork and apply for visas, and even bought tickets to the US for the family. In 2009, thirty years after Sergey and his family arrived in the United States, Sergey gave $1 million to the agency that helped his family escape Russia and resettle in Maryland. In 2017, when US President Donald Trump announced an immigration order banning travel to the United States from several Muslim-majority countries, Sergey joined the crowd of protesters at San Francisco's airport, saying, "I am here because I am a refugee."[1]

Settling into a small home in Baltimore, Maryland, Sergey's father became a mathematics professor at the University of Maryland, and Sergey's mom became a research scientist for NASA at the Goddard Space Flight Center—something that would never have been possible for Jews in Russia.

SCHOOLING: At his Montessori school, Sergey immersed himself in puzzles, math, and science projects; by middle school, his teachers had realized he was a genuine math prodigy.

Sergey sailed through high school, graduating early while also accumulating a year of college credit. This allowed him to graduate from the University of Maryland at only nineteen and become one of the youngest students ever admitted to Stanford's PhD program.

COULDA-WOULDA-SHOULDA ALERT! MIT rejected Sergey's grad school application. The school probably wishes it could get a do-over.

BOOKSHELF: No one captured Sergey's attention quite like Richard P. Feynman, Nobel Prize winner in Physics. During Sergey's childhood, Feynman published several books, including: *"Surely You're Joking, Mr. Feynman!": Adventures of a Curious Character* (1985) and *"What Do* You *Care What Other People Think?": Further Adventures of a Curious Character* (1988).

RICHARD P. FEYNMAN (1918–1988) was a world-famous theoretical physicist and a pioneer in quantum computing and nanotechnology.

As a child, he was raised to ask questions and challenge the status quo. By the time he was eleven, Feynman had spent hours taking apart radios and tinkering in his own makeshift laboratory. He even built a burglar alarm for his bedroom!

Brilliant by any standard, Feynman also experienced anti-Semitism. Even though he'd mastered a host of advanced mathematics, Columbia University denied his application. The reason? The school only allowed a certain number of Jews into their program and had already met that quota. Feynman attended MIT instead.

In the 1940s, during World War II, Feynman worked at the supersecretive Los Alamos National Laboratory, collaborating on the most top-secret project of the day—the atomic bomb. Serious business, to be sure.

Like Sergey, Feynman was not only smart, but also fun . . . and enjoyed picking locks and playing pranks.

Feynman's contributions to physics, nanotechnology, and quantum computing make him one of the greatest physicists in American history.

Larry Page (left) and Sergey Brin. (Photo by Randi Lynn Beach.)

LARRY PAGE

NAME: Lawrence "Larry" Page

DATE OF BIRTH: March 26, 1973

PLACE: Lansing, Michigan

FIRST COMPUTER: Age 6, Exidy Sorcerer

Exidy Sorcerer. (Photo by Wolfgang Stief.)

The Exidy Sorcerer was made by a video/arcade game company, Exidy. The Sorcerer was faster than its competitors and offered better graphics, which improved gaming. It was also the first plug-in-and-go home computer, which meant you could take it out of the box, plug it in, and start using it. Prior to this, setting up and using computers required technical know-how that the average person just didn't have.

And a SHOUT-OUT to NO SHOUTING . . . one of the key selling points for this computer was that it offered both upper- and *lower*case letters for typing. Phew! Pipe down, everybody.

FAMILY: Larry Page was born into a house where life revolved around technology. Larry's father was a computer science and artificial intelligence professor at Michigan State University. Talk about a pioneer! His mother had a master's degree in computer science and worked as a database consultant.

SCHOOLING: Larry also attended a Montessori school. "I think I was the first kid in my elementary school to turn in a word-processed document," Larry recalled in an interview. (In the 1970s and 1980s, most homework assignments and even research papers were still handwritten.) Larry graduated from the University of Michigan. He majored in both computer science and business.

YIKES ALERT! MIT also rejected Larry's grad school application. Double whammy!

INSPIRATION: At twelve years old, Larry read about an inventor named Nikola Tesla. As he leafed through the pages of Tesla's biography, Larry realized he wanted to be an inventor, too.

But Larry also quickly identified a tragic flaw in Tesla's story, which he saw as a cautionary tale. Even though Tesla was an amazing inventor, he never found fame or fortune through his work while he was alive.

"I realized I wanted to invent things, but I also wanted to change the world," Larry said. "I wanted to get them out there, get them into people's hands so they can use them."[2]

NIKOLA TESLA (1856–1943) was an extraordinary inventor, leading the way at the dawn of electricity. Filing more than seven hundred patents, Tesla invented the Tesla coil, which is still used in radio technology today. He also experimented with X-rays and radio waves, and laid the foundation for wireless technology.

But Larry Page was right. Tesla was never as successful, as well-known, or as celebrated as his nemesis: Thomas Edison. Sometimes Tesla even had to dig ditches just to support himself. He died in New York City in 1943, poor and suffering from mental illness.

BOOKSHELF: When Larry Page read *The Design of Everyday Things* by Donald A. Norman (1988), he became inspired by Norman's main premise: The user is always right.

Homework

THERE'S HOMEWORK and then there's HOMEWORK. There's the kind you knock off in five minutes and the kind that determines your whole entire life. As graduate students at Stanford, Larry Page and Sergey Brin faced the most epic homework assignment of all: the doctoral thesis.

It's like getting married—to your homework. First, you propose your carefully chosen topic to your professors. With their approval, you dive into the deep end of research, spending hours, days, weeks, months—however long it takes to break new ground, discover something, or deepen humanity's understanding of your topic. And if that's not enough pressure, the last step is to present your research to a panel of professors. Professors who are allowed to ask you questions about your

work—even challenge you—and you have to defend what you've learned!

Larry knew he needed to find just the right topic for his doctoral thesis. And he quickly turned his attention to the World Wide Web. In 1995, the web was only six years old—just a baby. Back then, in the ancient times of the internet, there were only about ten million web pages. And each page generally took thirty seconds to load—an eternity.

Today the web is made up of 4.73 billion web pages (and counting).

LINGO ALERT! The web and the internet are not the same thing. The internet is a giant network of computers, connected by cables and wireless signals. This *network* of networks allows computers to exchange information. The web is all of the content—documents, files, folders, web pages, and other resources—available via the internet, and is connected through links.

Still, when Larry looked at the web, he didn't just see a bunch of clunky, primitive web pages. He saw a mathematical graph. Each web page was a point on the graph. And just like the dots on a graph are connected by lines, the websites were connected with links.

Now came the questions. Were these links important? What could links tell us about a single page on the internet? Larry wanted to know more.

That's when he noticed something interesting: It was easy to look at a web page and see how many *outgoing* links it had to other sites. They were right there on the page in hypertext, ready to be clicked. But what Larry wanted to know was how many other sites linked back to a particular page? How many *incoming* links referred to a page? In 1995, nobody knew.

Hypertext is interactive text that leads you to another document, aka a web page. Oftentimes it's highlighted in another color. You can simply move your pointer to the hypertext and click to travel to the linked document, or web page, or information.

Larry explained it to a reporter like this: "The early versions of hypertext had a tragic flaw: You couldn't follow links in the other direction."[3] Larry wanted to reverse that.

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Backlinks

When you run for class president, you're not elected based on the number of leaders *you* think are brilliant. Instead, you are elected by the number of people who vote for you. Put another way, your popularity isn't measured by how many people *you* like; it's by how many people like *you*.

Studying the structure of the internet, Larry discovered a similar truth. It's not how many sites *you* link to that matters. What matters is how many sites link to *your* page. The more sites that link to you, the more relevant, substantial, and credible your site is. Each time a web page links to you, it's like a vote of confidence. The more votes a page receives, the more credible and important it must be.

This idea reminded Larry of something that was talked about a lot in his house when he was growing up: citation.

Suppose you are a scientist, brilliantly plugging away at research on climate change. You discover new evidence and prove new theories about how humans are changing the climate. You publish these discoveries in a scientific journal. Two things can happen. Your work can be ignored. Or it can be of such importance that scientists around the globe start talking about it. Building on your work, other scientists take your research to the next level with more investigations, experiments, and evidence. And when they publish their conclusions, they mention you. They *cite* your paper, your research, your contribution. Each mention is called a citation. And if hundreds and even thousands of scientists cite your work? It says the quality and credibility of your work is important. The more your work is cited, the more its importance grows.

Larry wondered if he could analyze the backlinks to figure out the credibility of a web page just as citation validated research. It was a big idea. And pulling it off would be complicated.

To accomplish this goal, Larry needed to search the World Wide Web, survey web pages, count their backlinks, and rank those results. This would require a sophisticated mathematical algorithm.

A mathematical algorithm is a specific set of steps that are followed in order to solve a math problem or to perform and complete a computer process. Another way to think about an algorithm is to look at it like a recipe for baking. Step-by-step instructions are followed to achieve a specific goal.

And he knew just the right mathematical mind for the job: Sergey Brin. It turned out that Sergey was still searching for his thesis topic, too. He found Larry's idea fascinating "because it tackled the web, which represents human knowledge," Sergey recalled to a reporter, "and because I liked Larry."[4]

But it wouldn't be easy. After all, they were planning to count and analyze all the links for the *entire* web, all ten million pages. They would need to deploy a crawler, harvest the links, store them, and then start analyzing their value. This meant downloading the World Wide Web—the whole thing.

Web crawlers have a couple of other cool names: spiders and internet bots! A crawler is nothing more than a program that visits web pages and reads them. Each crawler (or bot) is on the hunt for specific information. Once found, the spider then creates a database or index of what it has discovered, making the information easier to access.

The bandwidth required for such a task would need to be enormous, far beyond that of a typical Stanford student project.

This was a way bigger deal. Not to mention, they were going to move around a lot of data and would need a server that could store and handle that much information.

A server is a computer with a specific job or set of tasks that it performs. There are many different kinds of servers. Some store files or manage network traffic or deliver web pages, for example. The server's software determines what its job is.

Bandwidth is a measurement of how fast a computer can send data. It's often measured in bits per second. The smallest unit of data in a computer is known as a binary digit, or *bit* for short. A bit is either a *1* or a *0*. When you talk about bits per second, you are talking about how fast these smallest pieces of data are transmitted or received in one second.

Back in 1995, people had modems that connected to the internet over phone lines. The maximum speed was 0.056 megabits per second (Mbps). Today, most people in America connect to the internet with speeds of at least 20 Mbps. That means today we can download photographs in an instant. But back then, even downloading one low-quality image could take several minutes.

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