K–5 Reading Language Arts

ENGLISH

EUREKA! FILES

GRADE 4 UNIT 2 | READER

EDITION 1

GRADE 4 UNIT 2

EUREKA! FILES

Acknowledgement:

Thank you to all the Texas educators and stakeholders who supported the review process and provided feedback. These materials are the result of the work of numerous individuals, and we are deeply grateful for their contributions.

If you have further product questions or to report an error, please email **openeducationresources@tea.texas.gov**.

Contents

EUREKA! FILES

Eureka! The Art of Invention

Introduction

Welcome to the *Eureka! Files*.

As a contestant on *Eureka! Student Inventor* you are entitled to one (1) copy of the *Eureka! Files*. Guard it carefully. We've seen what inventing without any reading can look like and it's not pretty. You will need to refer to these articles throughout the Quest. You will not be able to complete the Wheel of Invention without them.

In this collection you will find:

- a carefully preserved transcript from an episode from last season that the network would just as soon forget
- uncensored, frank articles about your judges
- notes from experienced inventors
- information about inventions
- challenging vocabulary is in bold and defined in the glossary at the back.

These documents are only the beginning—remember that you can earn bonus points for reading and creating inventor cards for additional inventors. There are no rules against extra research in this Quest.

Good luck, contestants!

CAST LIST

Contestants:

Sam
Laura
Tyler
Maria
Alex

Other Characters:

Narrator
Host

Learn From Last Season: Bad Collaboration

Narrator: We are about to watch one of last season's building activities. Here students attempt to dip a paintbrush in a cup of red paint and then paint a red *X* on a piece of paper without any person touching the paintbrush directly. The contestants have just begun …

Sam: OK, OK, OK, I have such a good idea. We're gonna get everyone to stand in a line and I'm gonna tie a string around my wrist and attach the paintbrush to the string and then we're gonna tie everyone's wrists together, and—

Laura: Wait, I don't understand how that's gonna—

Sam: And then everyone will stand close together and there will be, like, a countdown and when we all swing our arms we'll launch the paintbrush into the paint—

Tyler: Oh, I have an idea! Let's just all make a pyramid with the paintbrush at the top—

Maria: You guys are being useless.

Laura: I didn't even say anything!

Maria: This is unnecessary. I say we forget the paintbrush and just put the paint in our mouths and then spit it onto the paper—

Alex: Oh! That reminds me of this really funny thing that happened at lunch yesterday! I was opening my milk, and I squeezed the box as I was opening it and there was this spurt of milk in my eye, but it was really funny. What's for lunch today?

Laura: I think it might be pizza day. Because it's Tuesday.

Maria: No, no, pizza is Friday. Tuesday is tacos.

Sam: We're gonna tie our wrists together!

Tyler: I don't think putting paint in our mouths is a good idea. Did anyone hear me about the pyramid?

Maria: I'm putting the paint in my mouth right now. Ew—gross, it tastes foul.

Narrator: Maria starts to cough and can't stop coughing.

Host: What's going on over here??

Narrator: The host listens in [their] earpiece.

Host: OK, I'm being told . . . the **producers** are saying that you cannot ingest the paint. That was not a good idea. It's toxic. It's poisonous.

Narrator: Everyone looks at Maria. She is turning blue.

Host: We have to get her to the doctor, right now.

Laura: Does that mean we lose?

Thomas Edison

Grouchy inventor Thomas Edison returns to anchor the panel of judges on *Eureka! Student Inventor*

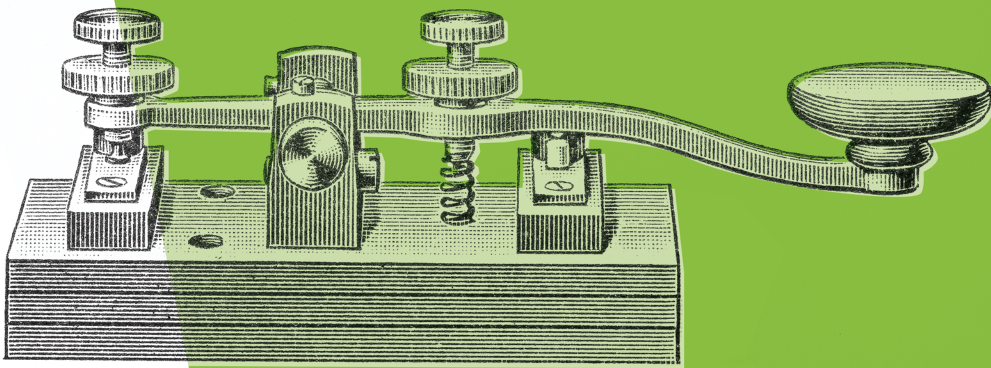
Producers are relieved to have Thomas Edison back on the judging panel this season on *Eureka!* Without a big name like his, they were concerned that even fewer people would tune in. For everyone's sake, the producers hope that this season's contestants pay Edison the respect he feels he deserves.

After all, many claim that Thomas Alva Edison is the most successful American inventor of all time. He **patented** over a thousand inventions in the United States. He had **humble** beginnings, however. Born on February 11, 1847, in Milan, Ohio, he was the last of seven children. His family was poor and his education consisted mainly of being homeschooled and reading his father's books. He got his first job when he was twelve years old, selling newspapers on the Grand Trunk Railroad. In his time off, he read in the public library and conducted chemistry experiments in the baggage cars. One of his experiments set the train on fire, but Edison wasn't **deterred**. Even then, he knew that you often have to figure out the wrong way to do something before you can find the right way.

One day he rescued a child from the path of a moving train, and the boy's father, who was trained to operate a **telegraph**, offered him lessons in telegraphy. He soon became a telegraph operator and before long was inventing remarkable improvements to the telegraph that got the attention of **financiers**. With their support, he opened a laboratory in Menlo Park, New Jersey.

His lab was the first of its kind. It was a busy place where experts collaborated, working on multiple inventions at the same time. Research and **marketing** happened under one roof. In this idea-rich environment, Edison invented the **phonograph**—the first device for recording sound!—and the incandescent light bulb, his most famous invention.

By the time he died, in 1931, Edison had patented an astounding 1,093 inventions in the United States, and more abroad. These also include the Kinetoscope (which launched the movie industry), the microphone, the rechargeable battery, and a cement manufacturing process. Edison believes this list cements his place in history.



telegraph

phonograph

Jacques Cousteau

Lover of croissants and aquatic life, seafaring Frenchman Jacques Cousteau returns to *Eureka!'s* judging panel

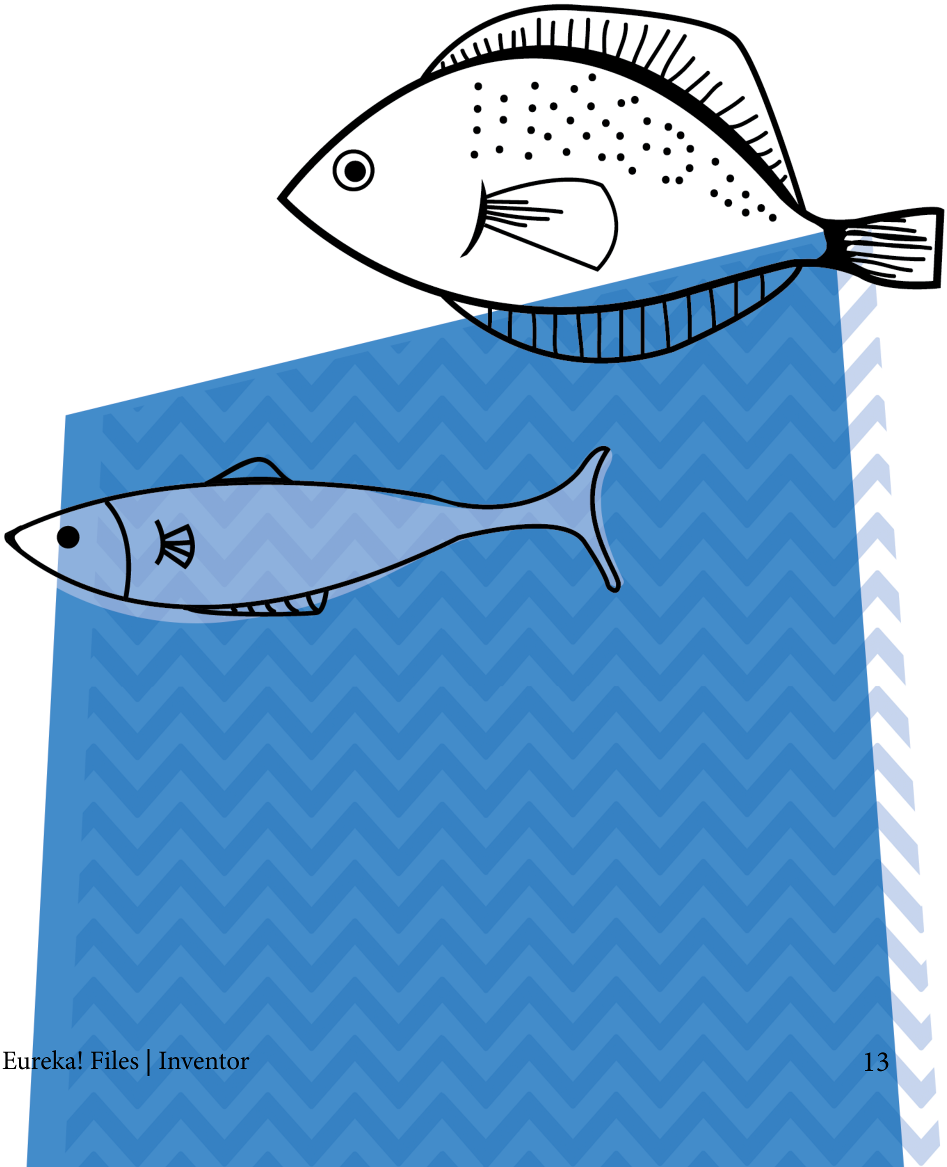
Producers are frustrated that Jacques Cousteau has returned this season as a judge on *Eureka!*, despite the fact that he was not invited back after the mess he caused last season. Jacques, however, is thrilled to be on the panel, and claims that this will be *Eureka!*'s most exciting season ever!

Jacques Cousteau likes excitement. Born on June 11, 1910, in the small town of Saint-André-de-Cubzac, France, Cousteau was a curious child. Although not a good student, he was always building things and taking things apart to see how they worked. At age twenty-six he was in a terrible car accident that required months of **rehabilitation**. Armed with a pair of goggles, he began swimming daily in the sea. He quickly realized that he wanted to be able to explore the ocean, but to do so he would need better equipment for breathing under water. So he decided to try inventing it.

Cousteau and his inventing partner developed the Aqua-Lung, which allowed people to stay under water while breathing from air cylinders (small tanks that can hold hours' worth of air). This advance opened human eyes to **aquatic** life in a new way, and also allowed for undersea rescues and recoveries that would have been impossible before.

Cousteau also helped invent a deepwater camera. (As an **avid** undersea explorer he wanted to share with the world what he experienced in person.) He increased interest in underwater archeology by **spearheading** the exploration of a famous Roman shipwreck. He went on to lead many more explorations, to write books, and to make films about his voyages and about ocean life. His television series, *The Undersea World of Jacques Cousteau*, was so popular it ran for eight years (a distant hope for *Eureka!*).

Jacques died at the age of eighty-seven in Paris, on land. But he was most himself when he was at sea. He once said, "From birth, man carries the weight of gravity on his shoulders. He is bolted to earth. But man has only to sink beneath the surface and he is free."



George Washington Carver

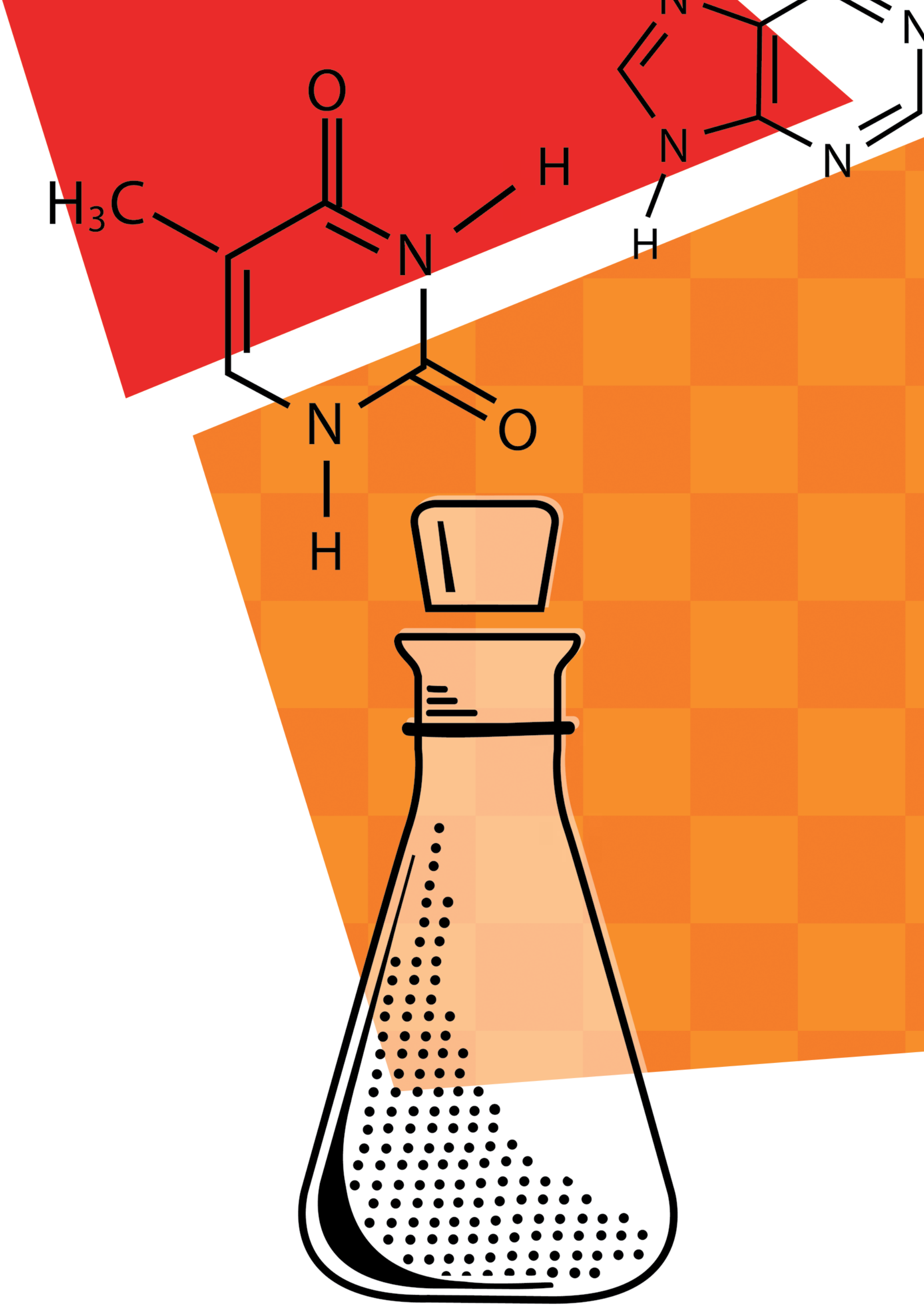
Peanut expert George Washington Carver joins *Eureka!* as judge, brings love of plants, general human kindness to program

Producers are pleased to announce that well-known inventor, professor, and all-around good guy George Washington Carver has joined the cast of *Eureka!* Carver brings to the judging panel a love of research, a deep knowledge of plant life and **agricultural** inventions, and a much-needed friendly and **optimistic** perspective.

A biography of George Washington Carver might as well also be a biography of the peanut. And the sweet potato. Carver **arguably** devoted more time, care, and love to these two crops—finding over 400 new uses for them—than any person devoted to plant life before or since. The road to **botany**-based greatness wasn't easy, however. Carver was born into slavery in Diamond, Missouri, around January 1864 (he wasn't sure of his exact birth date). He could not enroll at the first college to which he'd been admitted because of his race. When he finally started college in 1890, he studied painting and drawing (and piano!) because his school, Simpson College in Iowa, did not have a science program. But these studies led him back to science and nature when an instructor was impressed by his pictures of plants. The instructor pointed Carver toward Iowa State Agricultural College's botany program, where he was the first black student.

This is where his unlikely career **took root**. He was a talented **botanist** and was soon hired to lead the **prestigious** Tuskegee Institute's agricultural department. While at Tuskegee, Carver set out to help struggling farmers and **sharecroppers** in the South. He worked hard to get the latest information about farming methods to them, even in remote locations, to help them remain **self-sufficient**. Until this time farmers in the South had produced mostly cotton. Carver helped to introduce many more cash crops—crops that could be sold for money. He also instructed farmers to grow crops that broke down the soil, such as cotton one year, and then the next year to grow crops that improved the quality of the soil, such as peanuts, sweet potatoes, peas, and soybeans. This method of **crop rotation** kept the soil rich and **fertile**.

Carver became an inventor when he turned his attention to finding new uses for some of these new crops. He developed countless paints, dyes, and plastics made from peanuts, sweet potatoes, pecans, and soybeans. And, of course, he is often credited with inventing (or at least popularizing) peanut butter! When asked why he didn't try to make a personal **profit** from his inventions, he said, "God gave them to me. How can I sell them to someone else?"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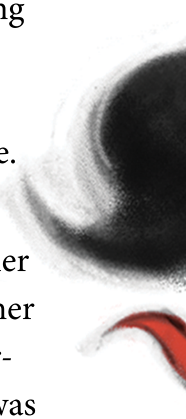
Hedy Lamarr

Brainy beauty Hedy Lamarr reluctantly agrees to judge season two of *Eureka!*, citing boredom and a salary that will help pay for her guilty pleasure: strudel



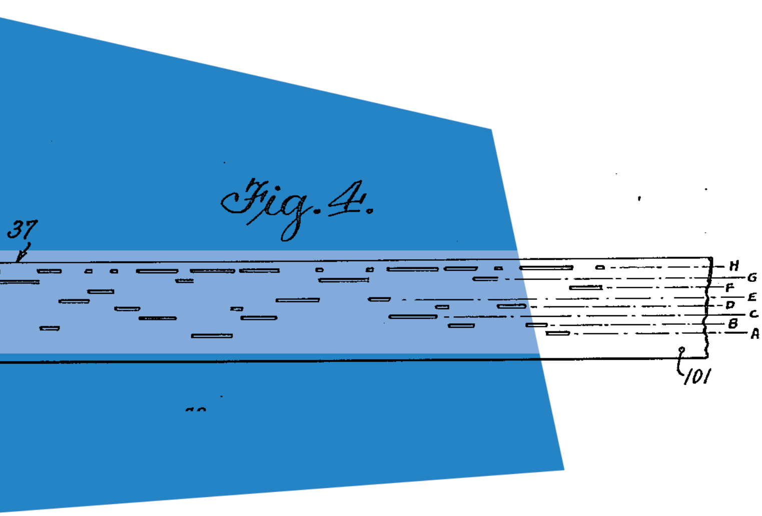
Producers are reportedly "OK" with Hedy Lamarr rejoining *Eureka!* as a judge. For her part, Ms. Lamarr claims "**indifference**" about returning to the panel. Her hopes for the student contestants include that they don't give her a head cold, or lice.

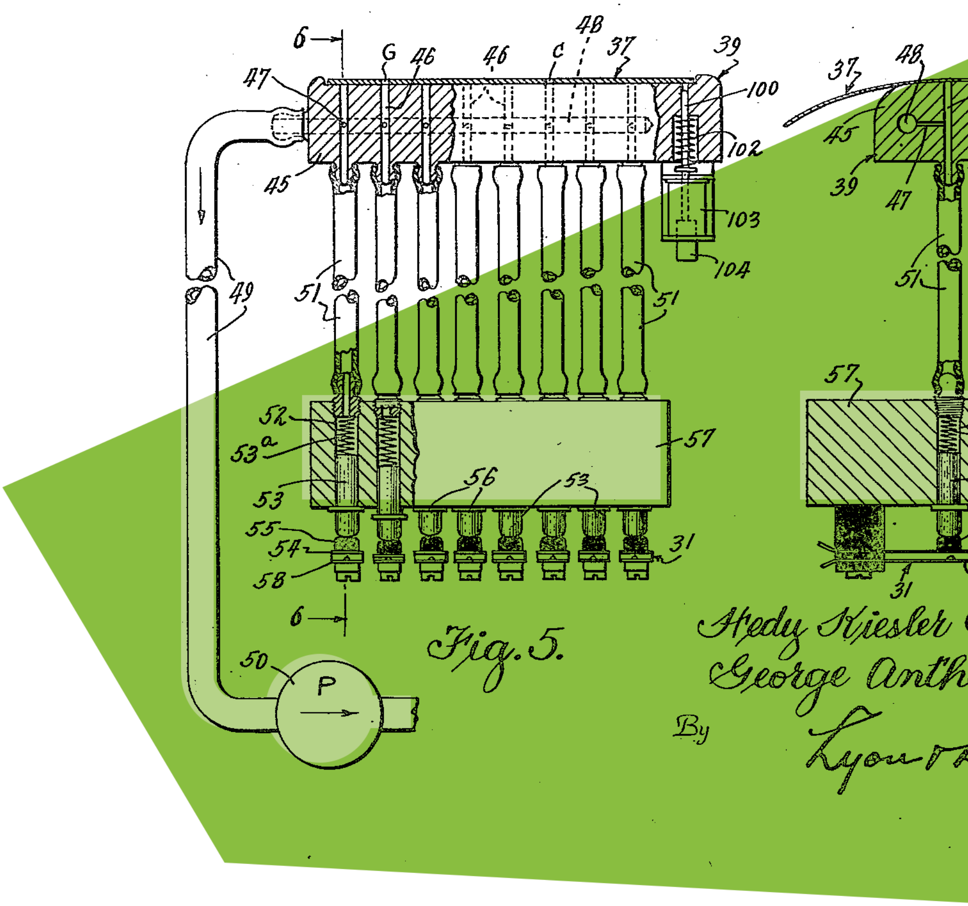
Born on November 9, 1914, as Hedwig Eva Maria Kiesler, to Jewish parents in Vienna, Austria, Hedy Lamarr changed her name in the early 1940s and became a movie star known for her stunning looks. But there was more to Hedy Lamarr than starring roles in popular Hollywood films and great beauty. She was also an avid inventor.

Her inventing began out of a need to entertain herself. She disliked Hollywood parties, so she had free time. She dedicated a room in her house entirely to inventing. Some of the things she developed there were everyday items (a better traffic signal, an improved Kleenex box—neither of which succeeded). But some of her other inventions were advanced technologies. She is best

known as an inventor for coming up with ***frequency** hopping*, the concept of changing the frequencies of the radio signals steering a torpedo so that an enemy would not be able to block them. She and her friend and inventing partner, a composer named George Antheil, stumbled on the idea when discussing a piece of music he'd composed that made use of **synchronized player pianos**. The two hoped to help America in World War II with their idea. It was acquired by the US Navy, but the navy never found a way to use it. It took twenty more years for the idea to be put to use, a major disappointment to Lamarr. Today a more advanced version of frequency hopping is used in wireless phones, GPS—anything that makes use of Wi-Fi.

Lamarr never profited from the idea and she was rarely appreciated for her brilliant mind. This oversight **irked** her to no end and certainly contributes to her sometimes, shall we say, "quick-tempered" responses on *Eureka!*





Lamarr's patent sketches

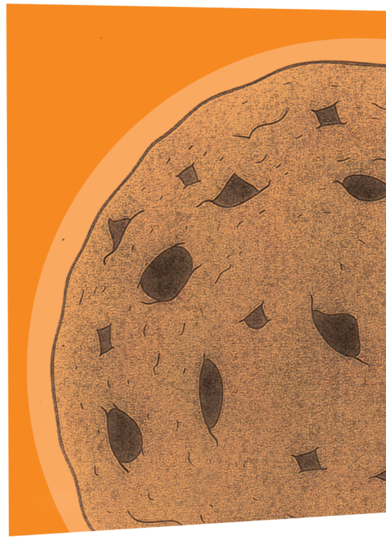
Ruth Wakefield

Good day, children. I am Ruth Graves Wakefield, and I am so very pleased to have the opportunity to clear up some disappointing untruths that people have written over the years about me and the invention of the chocolate-chip cookie.

I was born June 17, 1903, in East Walpole, Massachusetts. Articles about me almost always get that right, at least. But then the stories people tell! Here are some of the false stories that exist about me on the Internet. Some have claimed that the invention of America's favorite cookie was an accident. They say I ran out of nuts and, in a panic, chopped up a Hershey bar to throw into the cookie dough. It's utter nonsense! I kept a strict **inventory** of my food pantries' contents, and would certainly have noted an absence of pecans, cashews, or our own Professor Carver's peanuts prior to the dinner rush. I have also read that I mistakenly spilled chocolate chunks into cookie dough after being startled by a **malfunctioning** mixer. Having spent most of my life in kitchens—including my college years, during which I studied the household arts—I assure you that my response to a broken appliance would have been mild **irritation** followed by a call to the repairman.

Here is the truth about my cookie. It may not be the most thrilling story in the world, but I can't concern myself with that. In 1930 my husband Kenneth and I opened a restaurant near Boston called the Toll House Inn. The Inn was my pride and joy, and I took its operation very seriously. Some have suggested I was a bit of a tyrant with the staff, and I don't deny it. If a waitress wasn't able to fold a napkin exactly right, I would suggest that perhaps her skills were better suited to one of those "**greasy spoons**." Yes, I wanted my restaurant to be the best, and I'm fairly certain that's no crime. Therefore I was always trying to come up with new dishes and desserts to attract more business. So I set out, *quite* ***deliberately***, to invent a new cookie. And, after some trial and error with different ingredients, I created the chocolate-chip cookie in 1938 by improving a butterscotch cookie already on the menu. That's all there is to it.

And while I know quite well that my cookie did not change the course of history, I'll leave you with this question. If you were stranded on a desert island, which would you prefer to have with you—a box of light bulbs or a box of chocolate-chip cookies?



LIGHTBULB

The Light Bulb

BEFORE THE LIGHT BULB: Life in the Dark

For most of human history, people got up at sunrise and didn't do much after sunset because there wasn't much light indoors and traveling in the dark was dangerous—people could easily get lost or fall and hurt themselves.

Of course people lit their homes before the light bulb, but there were lots of **drawbacks** to these early sources of light. Candles, for example, didn't give off much light. Wood fires took a lot of effort to build and gave off unwanted heat when the weather was warm. Some species of whales almost became extinct because the oil in their blubber was used as fuel for oil lamps. Accidental fires were a problem with all of these light sources and with the gas lamps that became popular in the nineteenth century.

INVENTING THE LIGHT BULB: Edison's Innovation

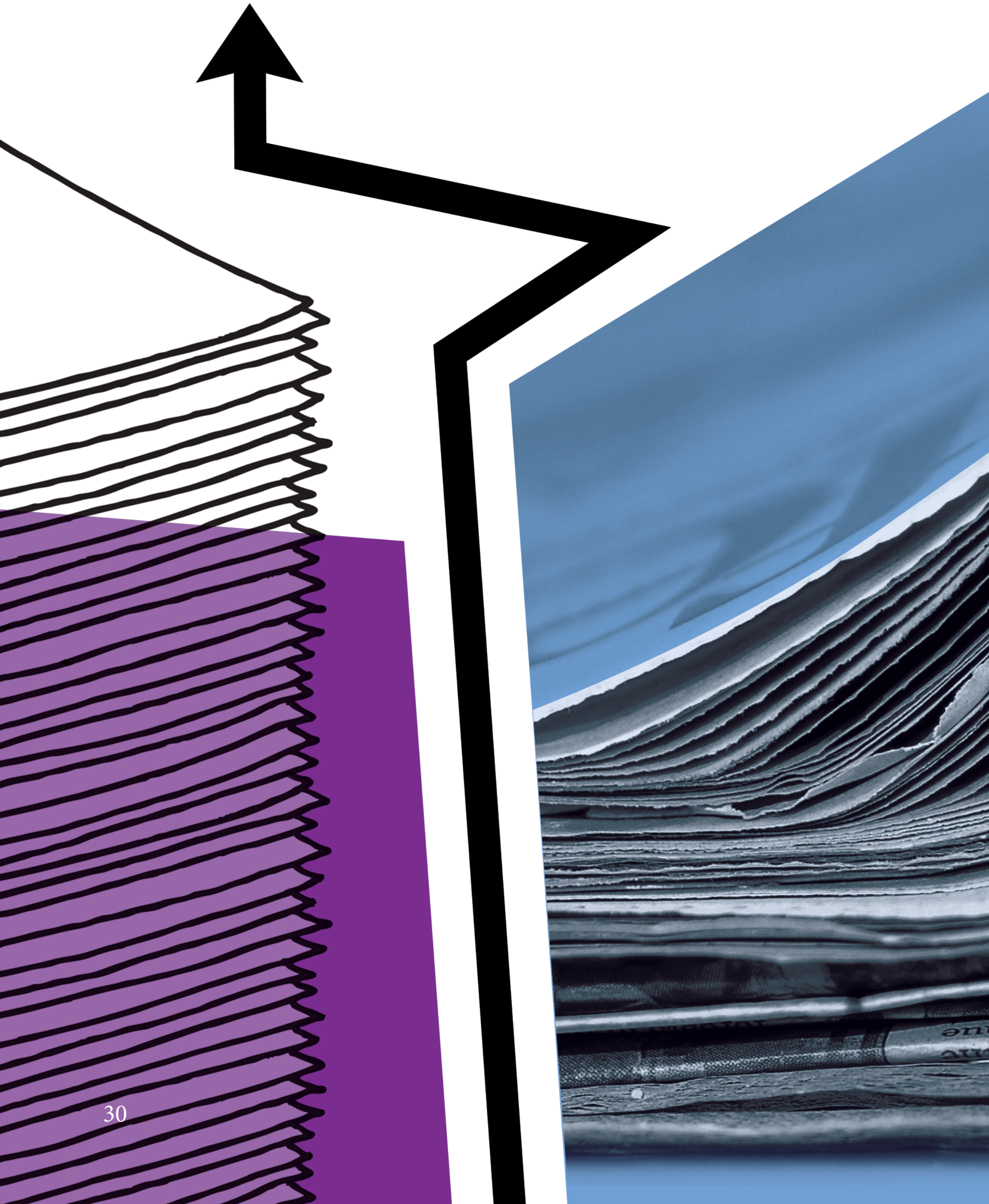
Electric lights existed before Thomas Edison's light bulb, but they were expensive and unreliable, and the lighting was very **dim**. One reason is that early inventors could not come up with a proper filament, which is the tiny wire that runs through the center of a light bulb. When the filament heats up, it glows, which is the source of the bulb's light. Before Edison, inventors made filaments from metals that would catch fire at the slightest heat. As a result the bulbs burned out very quickly, or the filament would burn so hot that the bulb would explode. Starting in 1878, Edison experimented for two years before he came up with a **charred** bamboo filament that provided 1,200 hours of **illumination**.

HOW THE LIGHT BULB CHANGED THINGS: The Impact

As a smart businessman, Edison realized the **potential** in selling both light bulbs and electricity. He quickly started a company to supply electricity to customers, and in 1882 his first power station lit up fifty-nine homes in New York City.

Almost every part of our lives has been affected by electric light. Think about all the things people do before sunrise or after sunset that would not have been possible before the light bulb. Today, factories that would have shut down at night can run around the clock because of the light bulb. The headlights on all sorts of vehicles, including ambulances and fire engines, allow for safe travel after dark. And nighttime activities that we take for granted, from sleepovers to concerts to reading in bed, would be more difficult or impossible without electric light. The light bulb also led to lots of other inventions, because once electric outlets were installed in homes, many inventors realized that things other than lamps could be plugged into these outlets. They then got busy inventing all sorts of home appliances—like the toaster, dishwasher, and electric fan—that make our lives easier and more comfortable.

PAPER



Paper

BEFORE PAPER: A Record-Keeping Nightmare

Throughout most of history, only a very small amount of human knowledge was ever written down. Most knowledge was communicated through spoken words. This meant that what a person knew was limited to what they could remember. One reason for this is that writing was very inconvenient. The writing surface made from the papyrus plant in ancient Egypt was extremely fragile. In other parts of the world people wrote on vellum, a **parchment** made from animal skin. But vellum was expensive and time-consuming to produce.

Almost two thousand years ago, around the year 105, a man named Cai Lun was keeping official government records for the Chinese Emperor He of Han. At that time in China people wrote on silk, which was very expensive, or on scrolls of bamboo, which were very heavy and difficult to manufacture. Cai Lun was frustrated with those choices and believed he could come up with a better option—a writing surface that was light, cheap, and easy to make.

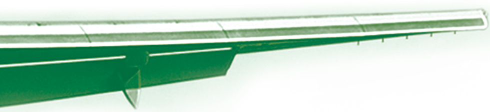
INVENTING PAPER: The First Paper

Cai Lun experimented with lots of different materials and methods before discovering his winning formula: He mixed tree bark, old cloth, and discarded pieces of rope and fishing nets in a big kettle of boiling water. As the water **evaporated**, he mashed up the mush that was left into a paste, which he then set to dry on screens in thin layers. As they dried, these layers of Cai Lun's strange mixture hardened into the first sheets of paper! Cai Lun's lightweight invention made writing, transporting, and storing records much easier. Emperor He was very pleased. He rewarded Cai Lun with great wealth. Neither of them could have predicted that a few hundred years later the Chinese would find two new uses for Cai Lun's invention that would become hugely popular: paper money and toilet paper.

HOW PAPER CHANGED THINGS: Portable Knowledge

Cai Lun's invention changed civilization. People could now spread knowledge of science, literature, and art over great distances by carrying paper documents with them when they traveled. Paper also helped people communicate across hundreds and even thousands of years because stories, poems, artwork, and history could now be recorded, stored, and copied over generations. By allowing political thinkers to share their ideas with many people, paper also toppled mighty kings and brought about great revolutions. For example, Tom Paine's *Common Sense*, a pamphlet that **inspired** the American Revolution, would not have been read up and down the thirteen colonies had it not been printed on paper. Paper is also used for fun—coloring books, comics, crosswords, and novels would not exist without paper! Through the spread of books, paper has enabled billions of people to learn to read, receive an education, and read for pleasure.

AIRPLANE



The Airplane

Leonardo's Flying Machines

Leonardo da Vinci (1452–1519), the famous artist who painted the *Mona Lisa*, was also a brilliant inventor. About four hundred years before the Wright Brothers' first flight, he was writing and sketching his ideas for man-powered flying machines. After carefully studying the way birds and bats fly, da Vinci drew plans for a human-powered flying machine with giant flapping wings. He also sketched ideas for a helicopter. The technology for this kind of flight didn't exist during his life, so his ideas were ahead of their time.

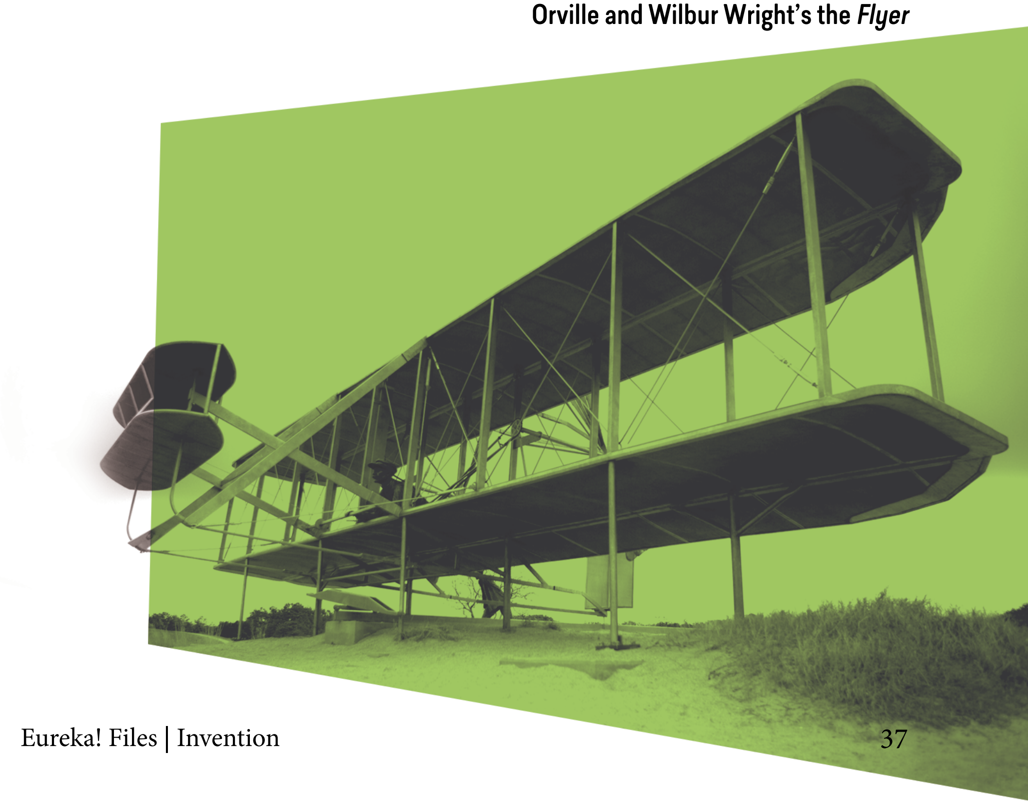
BEFORE THE AIRPLANE: Flights before the Wrights

Human beings first flew in the year 1783 in a hot-air balloon, but people wanted to do more than float in the sky. In the 1800s, a German man named Otto Lilienthal made over two thousand flights in gliders, motorless aircraft that ride air currents as a bird does in between flapping its wings. As new and more powerful engines were developed, lots of inventors attached them to aircraft frames and tried to fly. They failed because they didn't understand that successful flight requires a pilot to carefully balance and control the aircraft.

INVENTING THE AIRPLANE:
The Wright Brothers Take Control

Orville and Wilbur Wright understood the importance of control. That's why they practiced flying and steering gliders for two years before building the *Flyer*, their first motorized plane. They succeeded in keeping the *Flyer* **airborne** at Kitty Hawk, North Carolina, in 1903 because they had installed controls to keep the plane balanced and steady. Afterward they continued experimenting for two more years, eventually building the *Flyer III*. That plane had improved controls to adjust its pitch (lifting the nose or tail), roll (tilting from side to side), and yaw (steering right or left). These controls are still found on airplanes today. They help planes take off, fly, and land much more safely, especially in bad weather or high winds.

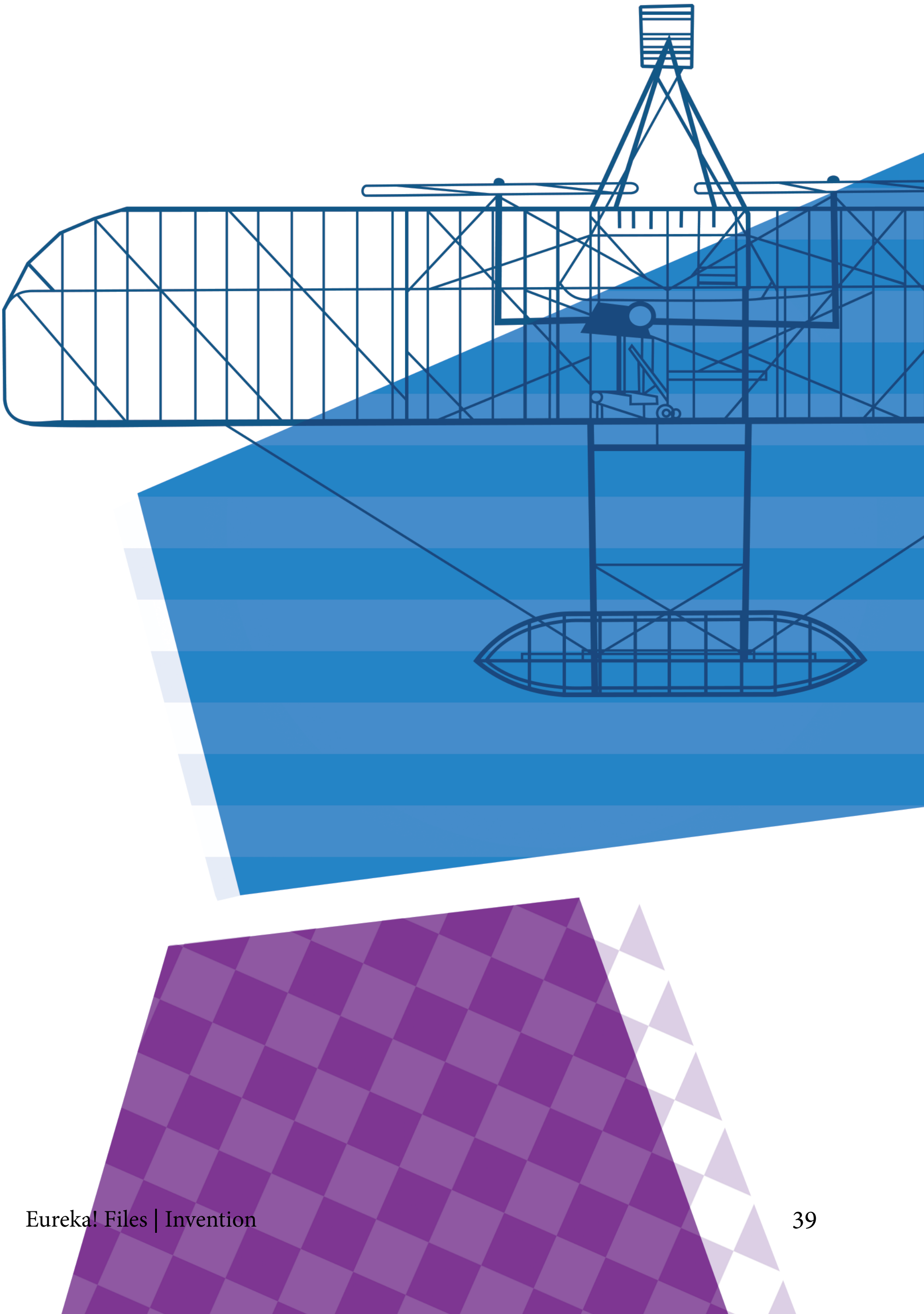
Orville and Wilbur Wright's the *Flyer*



HOW THE AIRPLANE CHANGED THINGS: The Sky's the Limit

It wasn't long before people saw the potential of the Wright Brothers' invention. Planes began carrying mail in 1911. In 1914, at the start of World War I, France and Germany used airplanes for military purposes for the first time, permanently changing how wars are fought. That same year a businessman in Florida started the very first airline, charging passengers five dollars to fly between St. Petersburg and Tampa, Florida. In 1927 Charles Lindbergh made the first flight across the Atlantic Ocean. By the end of the next decade, an airline called Pan Am was offering weekly passenger and mail flights between the United States and England. A trip that had taken a week by boat now took less than a day, with a few stopovers. Today that trip takes less than seven hours on a jet.

Hundreds of millions of people travel on airplanes every year. Airplanes have also saved countless lives by quickly bringing aid to areas hit by natural disasters. The Space Shuttle, a descendent of the airplane, sent men, women, and equipment, like communications satellites, into space. By making it possible for us to travel the world, the airplane has helped people appreciate and value different cultures, as well as understand what all people have in common.



CLOCK

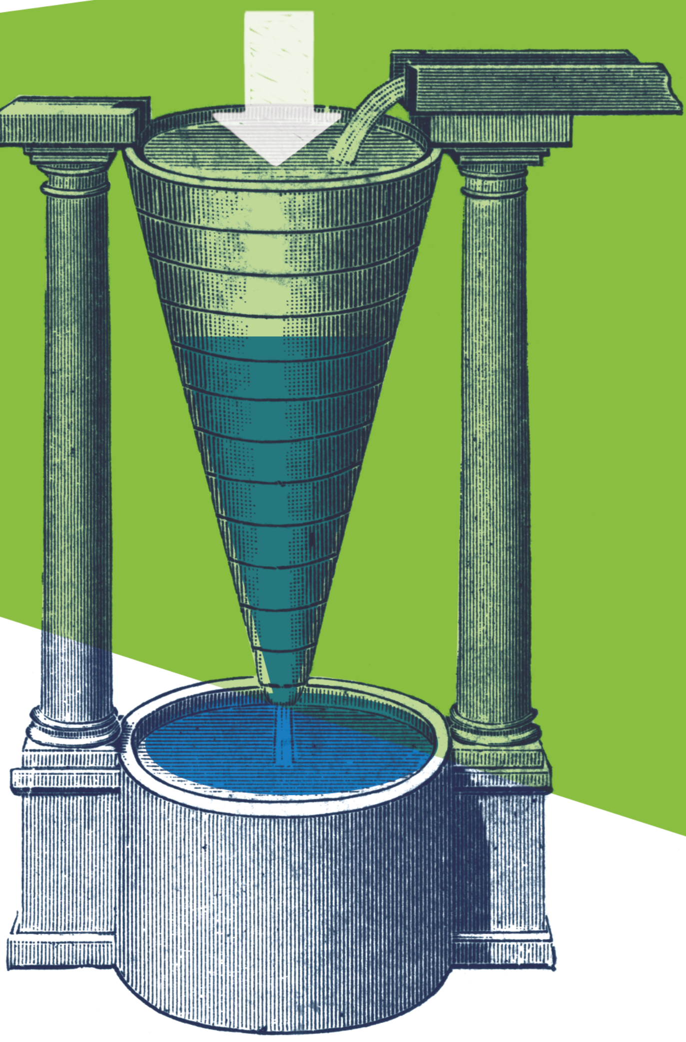
The Clock

BEFORE THE CLOCK: Telling Time

Even prehistoric men and women kept track of the passing of time. They noted the sunrise and sunset, the locations of the stars and planets, the changes in weather, and the cycle of the moon. These clues helped them know when to plant, when to hunt, and perhaps when to move to someplace warmer. As time went on, people began measuring smaller units of time with **sundials**, which told time using the direction and size of shadows cast by the sun. But sundials could not tell the exact time and were of no use on cloudy days or at night. As people started interacting with each other in more complicated ways, they divided the day into twenty-four hours and needed more accurate ways of keeping track of those hours.

INVENTING THE CLOCK: Water Clocks

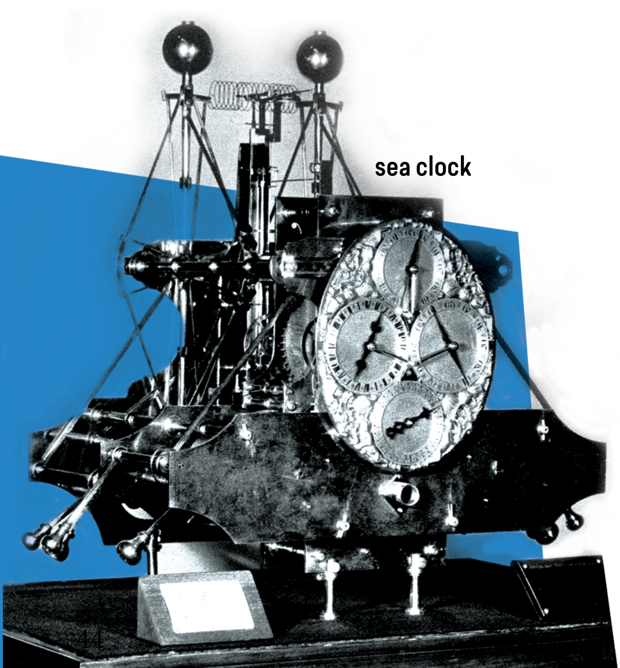
The next great innovation in timekeeping was the water clock. The first water clocks, which the Egyptians started using about 1400 BC, were simple bowls with holes carved into them. If you knew how long it took for all the water to flow out of a full bowl, you could measure the passage of time by checking the water level. Over time water clocks improved, and in the eleventh century a Chinese engineer named Su Song built a water clock that was an architectural and mechanical wonder. Su Song's clock was powered by a waterwheel and stood forty feet high. **Intricate** puppets playing musical instruments emerged from five different doors to announce each hour. It also displayed the positions of the planets. Water clocks like Su Song's were the most accurate timepieces for hundreds of years.



water clock

Keeping Time at Sea

As the centuries marched on, clocks became more accurate as water power was replaced by springs and **pendulums**. However, these early clocks were very breakable and didn't work on ships because of all the motion caused by the sea. Sailors were desperate for a clock that would keep working on a ship. Knowing the time at home by using such a clock, and the time on board, which they could calculate using the stars, would let them figure out their ship's exact longitude (its location on one of the horizontal lines that circle a globe). Not knowing longitude often led to shipwrecks or ships becoming lost at sea. After more than 1,400 British sailors drowned in 1707 because of the "longitude problem," a carpenter named John Harrison spent almost fifty years designing clocks and watches that kept time at sea. His inventions helped sailors navigate safely.

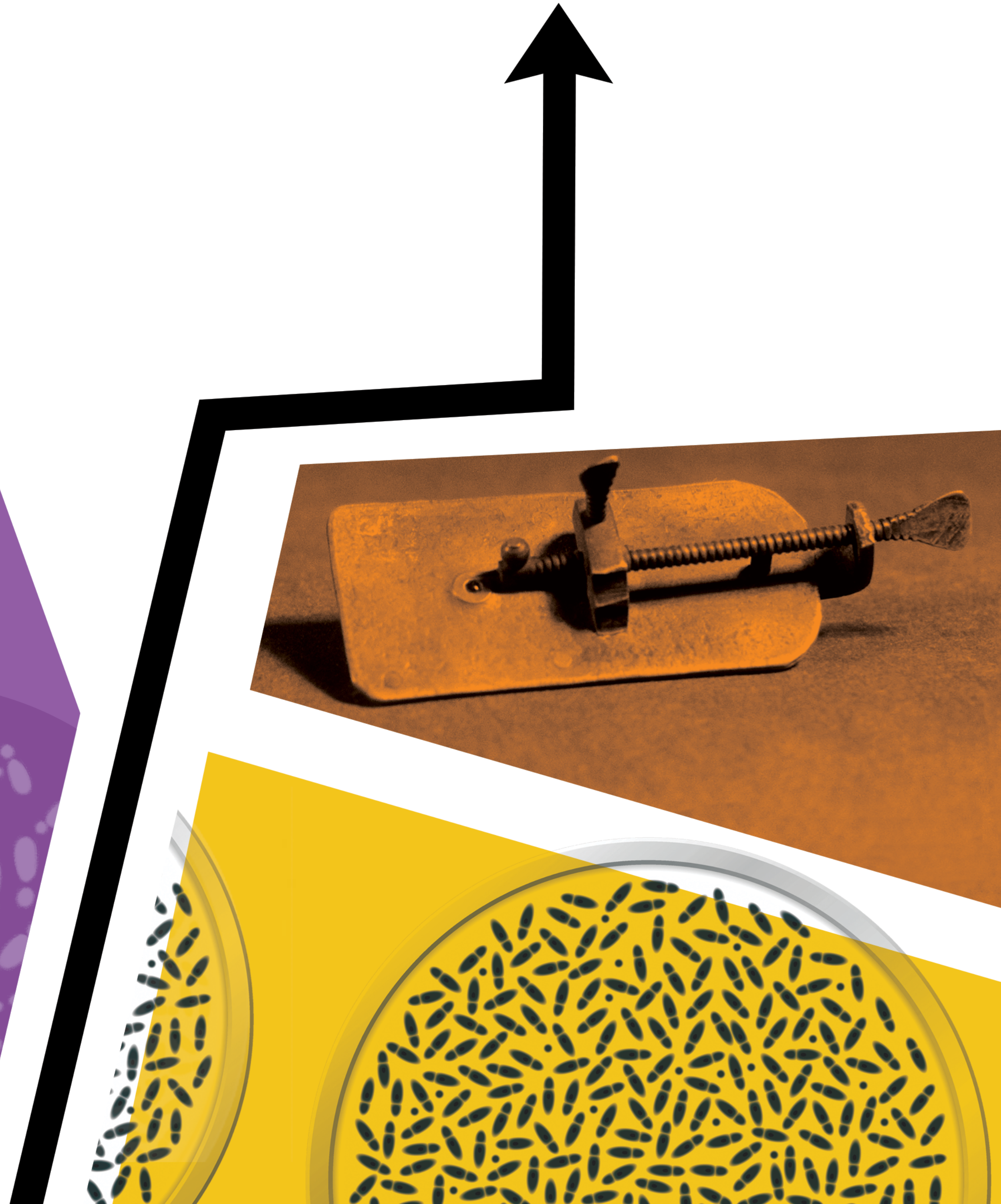


sea clock

HOW THE CLOCK CHANGED THINGS: Time Marches On

As the number of clocks in the world continued to grow, more and more people were better able to coordinate with one another because of their shared understanding of time. Friends who planned to get together at 10:30 a.m. instead of "midmorning" were much more likely to arrive at the same time. Clocks also made workplaces run more smoothly because bosses could plan and assign work knowing exactly when their employees would be arriving and leaving. Railroads and airlines, which need to operate according to schedules, would not have been possible without clocks. And television stations need clocks to schedule their programming. Let's just hope the clock doesn't run out on *Eureka!*

MICROSCOPE



The Microscope

BEFORE THE MICROSCOPE: Bad Air

One reason doctors and scientists had difficulty curing many diseases before the invention of the microscope is that they couldn't see the tiny **organisms** that often spread sickness. Until about 150 years ago, most people believed that dirty, smelly air rising from rotting plants or dead animals formed a poisonous gas that spread illness. This idea of bad air causing disease made some sense at the time. After all, people could smell the bad odor of rotten meat, but could not see germs. A few scientists in ancient and medieval times suggested the existence of tiny living organisms, but not many people believed them. "Seeing is believing," they thought. And by the middle of the seventeenth century, no one had figured out how to examine tiny objects and organisms.

INVENTING THE MICROSCOPE: An Amateur Inventor

In 1654 a young man named Antonie van Leeuwenhoek opened up a shop in Holland selling cloth and textiles. Although he was a successful merchant, he was more interested in science, and began experimenting with glass lenses, like those used in eyeglasses. Van Leeuwenhoek manufactured a tiny lens that was double convex, which means the glass bulged out on both sides of the lens, like two tiny domes. He attached his lens to a brass plate and eureka!, he'd made a microscope. He started studying the tiniest details of organisms like mold, bees, and lice, while working on improving his lenses. By 1676 he had invented a microscope so powerful that he was able to see single-celled organisms, like bacteria. He wrote to a group of famous scientists in London about his discoveries, but they didn't believe him. "Seeing is believing," they thought. But when they sent representatives to look through the microscope themselves, they realized the importance of van Leeuwenhoek's invention.

HOW THE MICROSCOPE CHANGED THINGS: Tiny Organisms, Huge Impact

Over the years the microscope has been an important tool in great scientific and medical discoveries. Thanks to the microscope, nineteenth-century scientists like Robert Koch and Louis Pasteur were able to see the bacteria that cause many deadly diseases. Once these bacteria had been identified, scientists invented **vaccines** that saved millions of lives by preventing these diseases. The microscope has also helped the environment. For example, by studying river water samples, scientists have been able to analyze and improve the health of **ecosystems**.

Van Leeuwenhoek's most powerful microscope had a magnification of 270, which means tiny objects appeared 270 times their actual size. Today's most powerful microscopes can achieve a magnification of ten million. Modern microscopes have more uses than van Leeuwenhoek could have imagined. They are used to manufacture tiny computer parts. They also make possible many complicated medical procedures, like surgery on the eyes and blood vessels.

RADIO

The Radio

BEFORE THE RADIO: Wired!

For most of the nineteenth century, many Americans lived fairly **isolated** lives. They may not have ever traveled more than twenty or thirty miles from their homes. For entertainment they visited with neighbors, played cards and games, and maybe danced, sang, and played music together. Concerts and the theater were mostly for those who lived in cities. People didn't have much reason to communicate with those outside their communities, and when they did it was by mail, which could take weeks or months to arrive.

In 1861 the Western Union Company completed the first transcontinental electric telegraph, connecting the East and West Coasts of the United States. The telegraph was a machine that sent coded messages over a wire in the form of electricity in a matter of minutes. A telegraph operator tapped out the message in code in one city, and then a second operator decoded and wrote down the message in another city. At the

time the telegraph was the fastest and most efficient means of communicating over long distances, but putting up the wires (and making sure they stayed up) was so expensive that telegraph companies did it only where there were significant populations. This left many Americans who lived far from big cities out of reach of the telegraph.

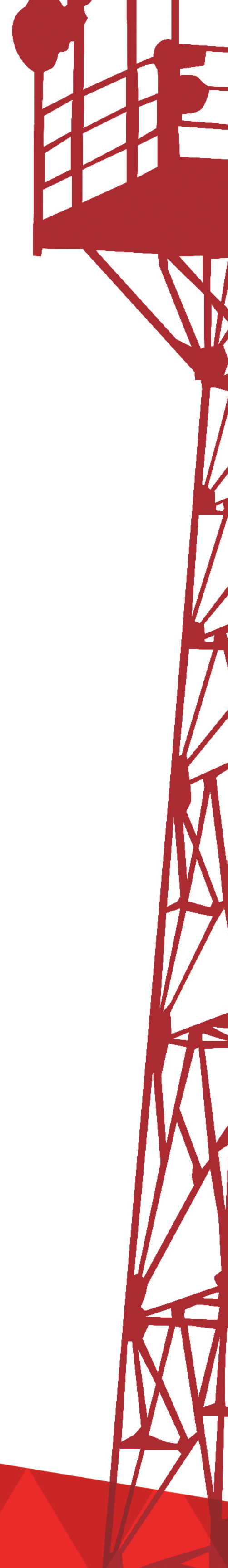
INVENTING THE RADIO: Wireless

In 1894 a young man in Italy named Guglielmo Marconi read a book that explained electromagnetic waves—that's electricity that travels through the air. He reasoned that if electricity could travel through the air without a wire, then he could send telegraph messages wirelessly. He quickly got to work in his attic building a wireless **transmitter** (to send messages) and a wireless receiver (to receive messages). Soon Marconi was sending wireless signals across the room, and by 1895 he was sending them over a distance of a mile and a half.

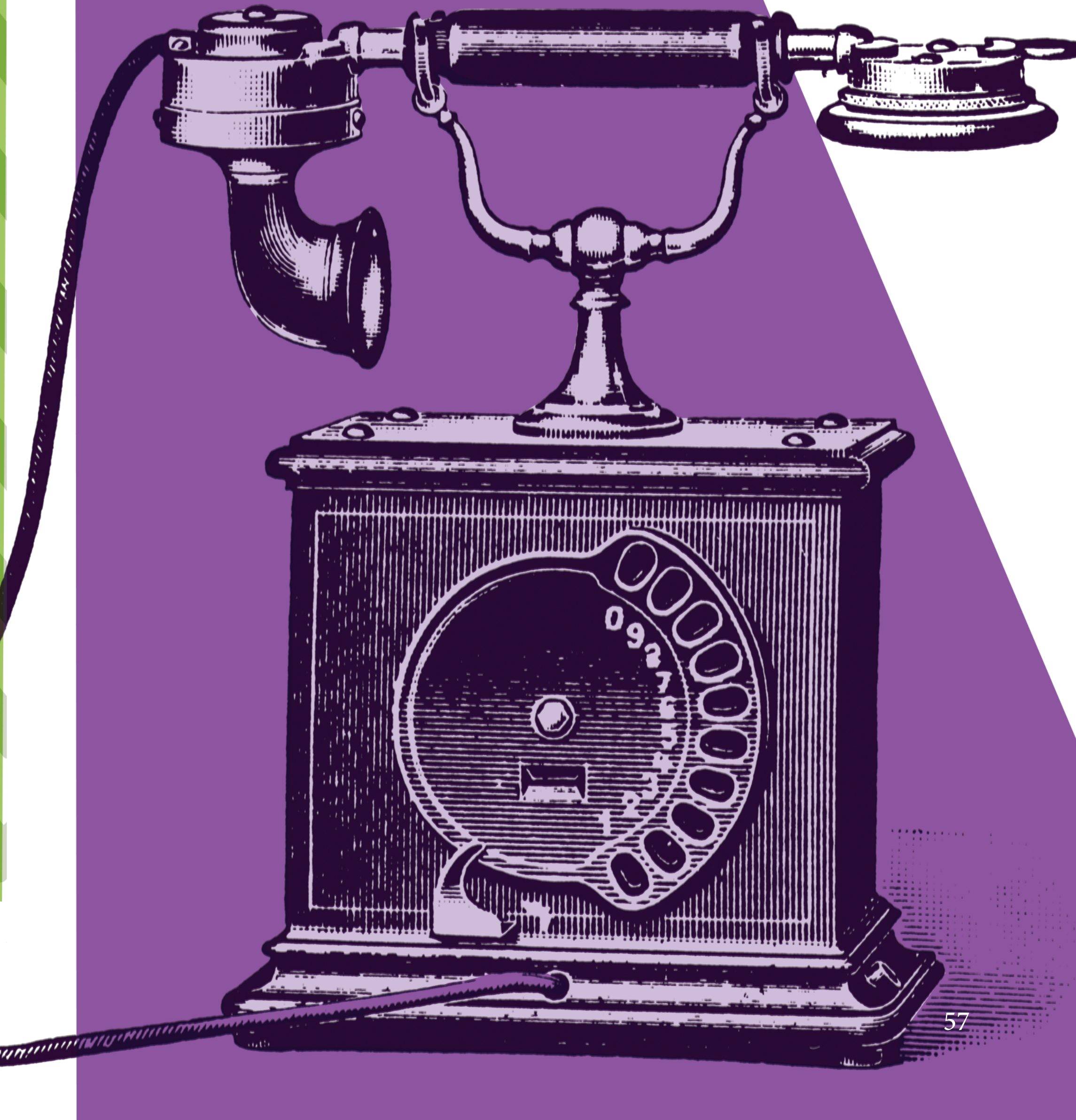
Marconi wrote to an Italian official asking the government for money to help him further develop his invention. The official thought he was crazy, so Marconi moved to England, where he found people who believed in him. In 1898 Marconi sent a wireless message across the **English Channel** to France, and in 1902—only eight years after he built his first machine in the attic—Marconi sent a wireless message all the way across the Atlantic Ocean! Soon scientists and businesspeople realized that the future of Marconi's technology was in sending sound directly to receivers in people's homes. These receivers were called radios.

HOW THE RADIO CHANGED THINGS: Radio Waves of the Future

The first commercial radio station began broadcasting in 1920, and by 1930, long before televisions were available, radios were in twelve million American homes. Radio stations broadcast news, music, comedies, adventure shows, game shows, soap operas, talent contests—almost everything you can see on TV today. Lots of families gathered in the evenings to listen to the radio the same way many families now watch TV together. And along with the movies, the radio created national celebrities, as many radio performers became superstars. Today the electromagnetic waves that Marconi first sent across his attic are also used for cell phones, GPS, radar, and TV (including *Eureka!*), and even to control satellites in outer space.



TELEPHONE



The Telephone

BEFORE THE TELEPHONE: Voiceless Communication

For thousands of years, the only way for most people to stay in touch with those who lived far from them was through the mail, and letters could take weeks or even months to arrive. In the middle of the nineteenth century an invention called the telegraph was revolutionizing long-distance communication around the world. With the telegraph, an operator in one city could transmit a message to an operator in another city in minutes by sending an electric current over a wire. The telegraph did have some drawbacks, however. Most importantly, the telegraph could not transmit sound—only a complicated code of clicks that few people could understand. People couldn't hold back-and-forth conversations over a telegraph line. They had to go to special telegraph offices to give their messages to an operator to send, which meant messages were never completely private. And sending a message over the telegraph might require a lot of traveling if you didn't live in a city or town with an office.

INVENTING THE TELEPHONE: The Voice!

The telegraph proved that electrical signals could be sent across a wire. Alexander Graham Bell aimed to send the human voice across a wire by turning it into electrical signals. In 1875 he was **tinkering** in his lab when he accidentally spilled acid on his pants. He called to his assistant, Thomas Watson, who was in the next room, where the receiver of Bell's invention sat on a table. Eureka! Watson heard Bell's voice coming out of the machine. The first phone call!

Bell worked on improving the invention and the next year, he and Watson had a telephone conversation over a distance of two miles. When Bell spoke into the telephone, his voice caused a thin piece of parchment (the **diaphragm**) to vibrate. A magnet turned those vibrations into electricity that traveled over the telephone line. At Watson's end, a second magnet and diaphragm turned the electrical signal back into sound vibrations.

HOW THE TELEPHONE CHANGED THINGS: A Ringing Success

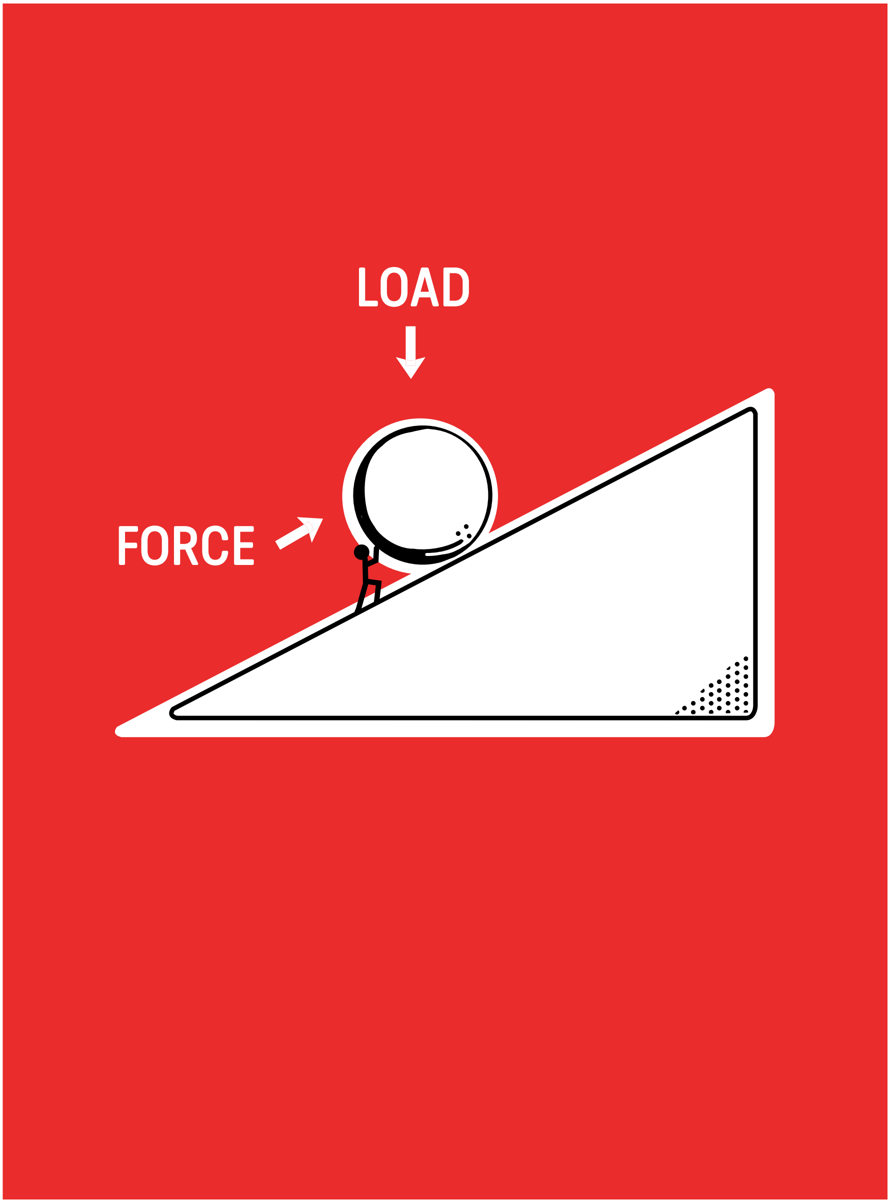
By 1886 more than one hundred thousand Americans had telephones in their homes. The country, and eventually the world, became much more connected because people were able to pick up their phones and speak to anyone anywhere. Businesses saved money, as meetings that had once required long-distance travel could now be held over the phone. People who lived in isolated areas were now able to call for help in an emergency. News traveled more quickly and long-distance friendships became possible. Eventually the telephone put the telegraph out of business and became one of the most successful inventions of all time.

The Inclined Plane

An inclined plane is really just a ramp—a flat surface tilted so that one side is higher than the other. It is the one simple machine that doesn't move, but it sure makes moving things a lot easier.

Here's an example of how it might be used: There is a rumor going around that the network is thinking of replacing *Eureka!* with a monkey modeling competition (*Next Top Monkey Model*, in case you were wondering). Now let's say some network **bigwigs** are planning to load a barrel of beautiful **baboon** contestants into the trailer of a truck to bring them down to the studio. (Don't worry, the barrel is equipped with air holes, and magnifying mirrors for last-minute makeup application). The barrel may be too heavy to lift into the truck, but it's probably not too heavy to roll up an inclined plane into the trailer. That's because by lifting the barrel, you are carrying the entire weight of those stunning **simians**, but when you roll the barrel up the inclined plane, a big part of the weight is now supported by the plane (and not you). That's the *mechanical advantage* of the inclined plane—it helps you accomplish a task *indirectly* (by rolling the barrel instead of lifting it) and with less effort.

You probably encounter inclined planes all the time. A winding trail up a mountain is an inclined plane. So is a wheelchair ramp. The inclined plane is a tool that has been around a long, long time. Archaeologists tell us that humans were using inclined planes to move things way back in prehistoric times. The ancient Egyptians hauled stones to build the pyramids by sliding them up inclined planes. And just the other day, some desperate TV producers used an inclined plane to roll a barrel of monkeys into a truck. For *Eureka!*'s sake, I hope those **primates** aren't ready for prime time.

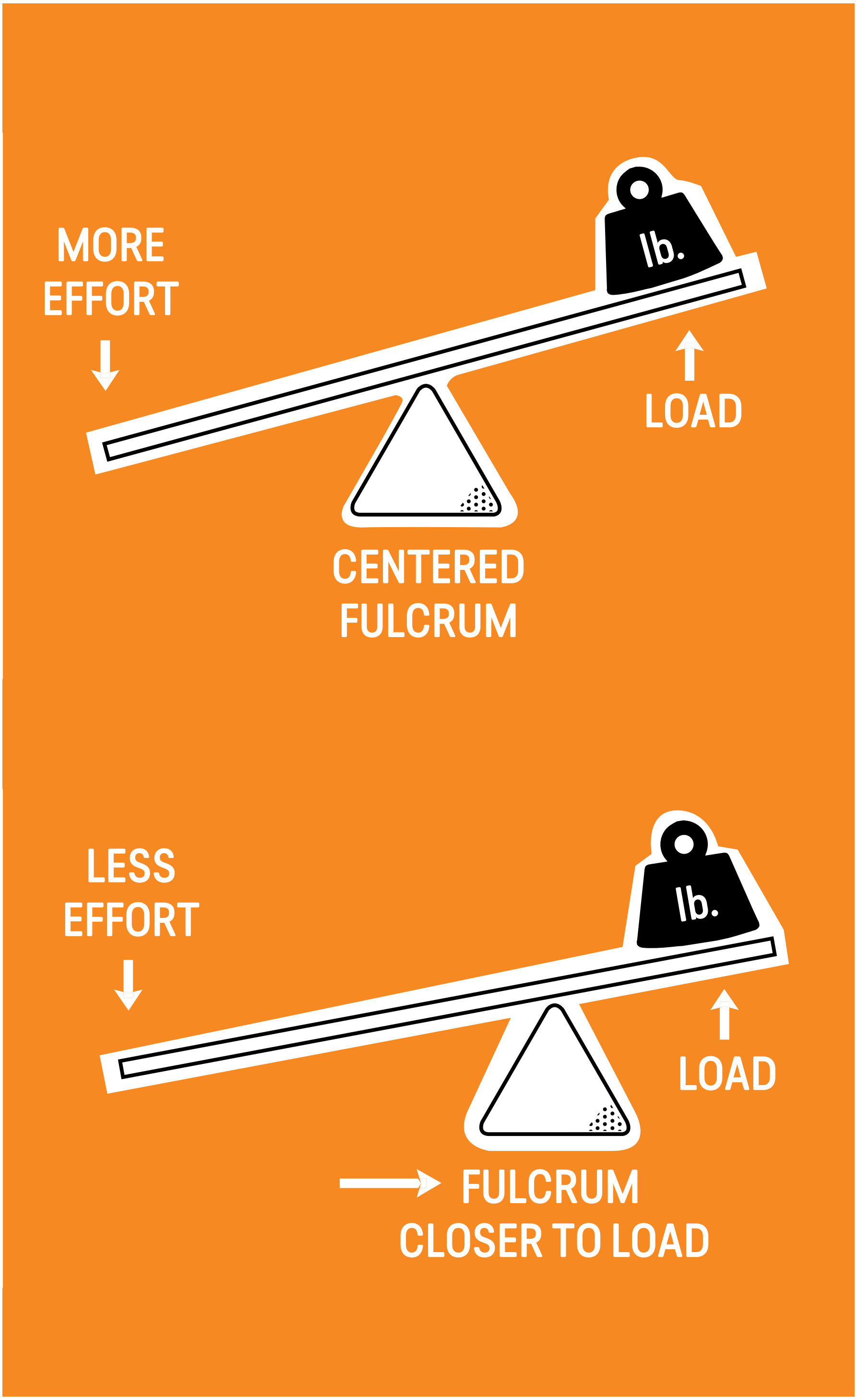


The Lever

We don't know who made the first lever, but the ancient Greek scientist Archimedes figured out the math of how levers work. He once said, "Give me a lever long enough and a fulcrum on which to place it, and I shall move the world." He understood the power of a lever (and a fulcrum), a small force can lift up a massive object.

A lever consists of a beam and a *fulcrum*, which is the hinge or support that the beam rests on. The object lifted by the lever is called the *load*, and the work that you put in to operate the lever is called the *effort*. Like all the simple machines, the lever provides a mechanical advantage allowing you to do more with less effort. The size of the mechanical advantage depends on the location of the fulcrum. The closer the fulcrum is to the load, the easier it is to lift the load by pushing down on the other side of the lever. A playground seesaw is one example of a lever.

Now, suppose Professor Carver hears that Mr. Edison is interested in planting a garden. The professor is thrilled to share his passion for agriculture with his friend, so he brings Mr. Edison a gift to help him get started: a two-hundred-pound bag of **manure**. Mr. Edison isn't around, so Professor Carver decides to leave the bag on Mr. Edison's dressing room coffee table. Perhaps the bag is too heavy for the professor to lift onto the table, but if he manages to get it onto one end of a lever beam and place a fulcrum near the end of the lever closest to the load (the bag), he can push down on the other end to lift the manure, and then just slide it onto the coffee table. The closer the fulcrum is to the bag of manure, the easier it will be for Professor Carver to lift the bag. Let's hope Mr. Edison enjoys his gift!

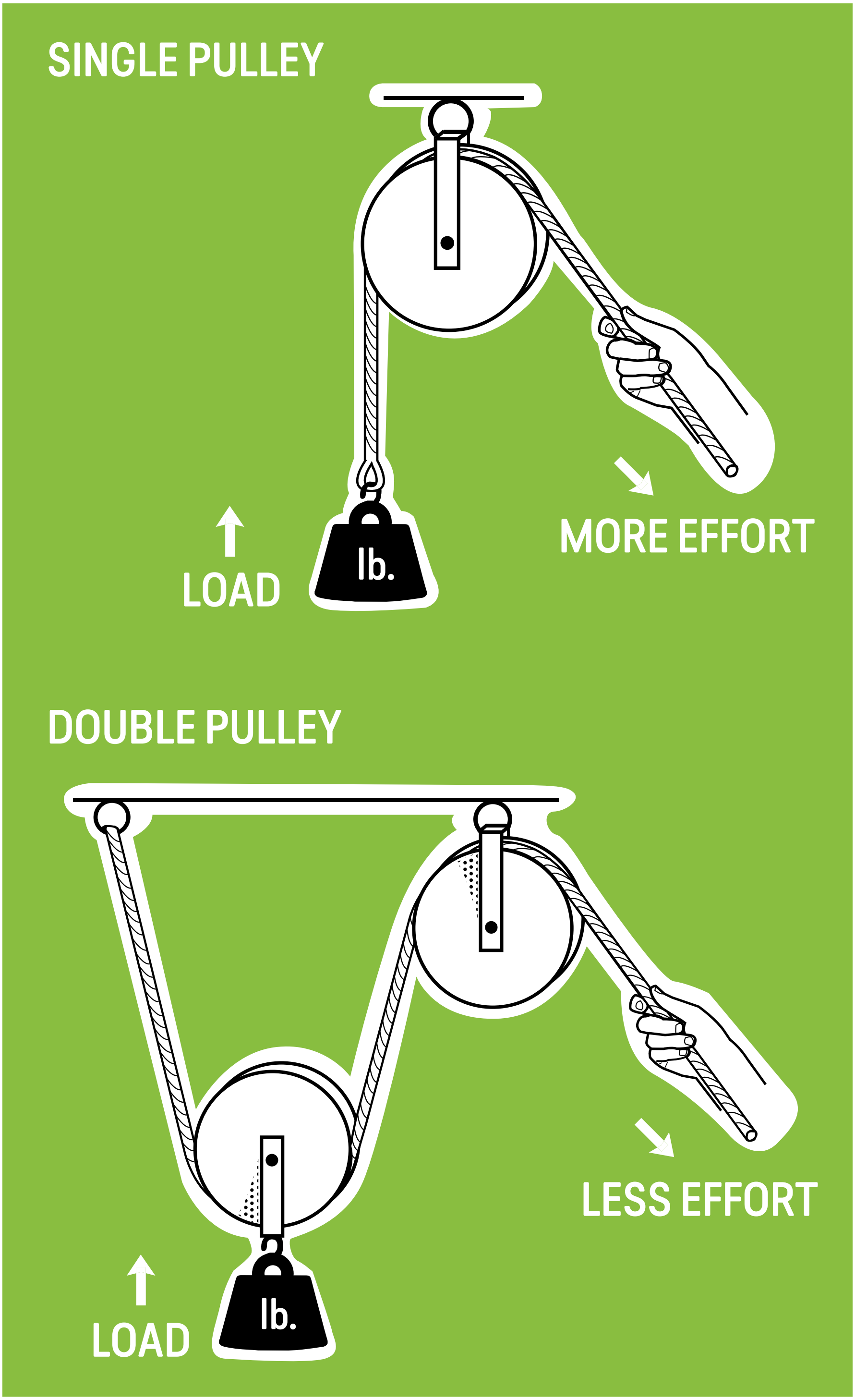

MORE EFFORT
lb.
LOAD
CENTERED FULCRUM
LESS EFFORT
lb.
LOAD
FULCRUM CLOSER TO LOAD

The Pulley

Ever opened up the blinds? You've used a pulley. Ever flown a flag up a flagpole? You've used a pulley. Ever had a dream where you were being chased by a tiger? No pulley there, but it happens to the best of us. The important thing to remember is that a simple pulley is a wheel with a groove in it that is attached to something sturdy and has a rope running over it. The elevator is another important invention that makes use of a pulley.

How does it work? Last season Jacques needed to load two hundred pounds of jellyfish food onto his boat, the *Calypso*. As we know now, that was a big mistake, but let's take a look at how he did it anyway. First he hoisted the bag onto his shoulder and tried carrying it up the gangplank, but it was too heavy. Then he attached a simple pulley to a beam hanging over the edge of the boat. He tied the jellyfish food to one end of the pulley's rope and pulled on the other end. This way he was using his body weight to help lift the jellyfish food, but the bag was still too heavy.

Don't worry, though. Jacques knew that by attaching one end of the pulley's rope to the beam, and then hanging a second pulley from that rope, he could make a double pulley, which would give him a mechanical advantage. That means the machine lets him do more with less effort. Specifically, with a double pulley, a bag that actually weighs two hundred pounds feels as if it weighs only one hundred pounds. Unfortunately, that mechanical advantage almost got *Eureka!* canceled for good!


SINGLE PULLEY
lb.
LOAD
MORE EFFORT
DOUBLE PULLEY
lb.
LOAD
LESS EFFORT

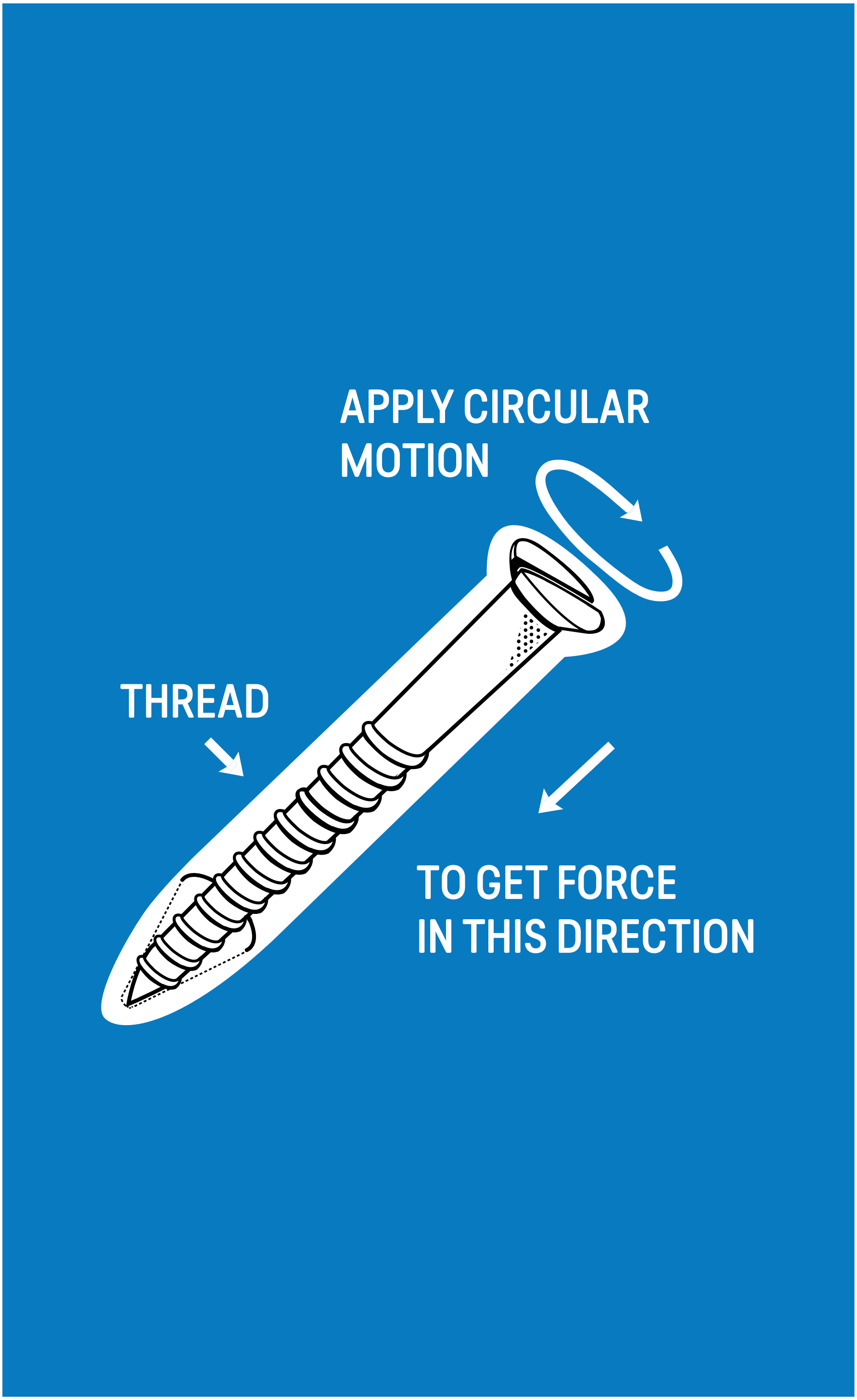
The Screw

The humble screw is everywhere. Hardware stores have thousands of them. The desk or table you're sitting at was probably put together with screws. But don't take the screw for granted; it is actually a remarkable simple machine that makes tough jobs a lot easier. For example, a lid is attached to a water bottle through a screw.

Just ask Professor Carver. Not surprisingly, he is the only judge who regularly offers to pitch in to help the *Eureka!* construction crew build the set. Today the crew is working on a wooden banner that will hang over the judges' table. Professor Carver has generously volunteered to fasten together two planks of wood that will make up part of the letter *E* in *Eureka!*

Using a screw and a screwdriver will make the job so easy that Professor Carver will be able to finish the whole *E* and maybe even start on the *U* during his break (while the other three judges drink coffee and eat pastries). After all, it doesn't take a lot of strength to turn a screw clockwise with a screwdriver, but the screw then converts that circular movement into a powerful force that drives it through the wood. That's called a mechanical advantage. The advantage depends on the space between the threads, the length, and the width of the screw. If the threads are close together, it will be easy to turn, but will take more turns. If the space between the threads is wider, it will take more effort to turn, but take fewer turns.

A final word: one of your esteemed judges should thank his lucky stars for this simple machine. We won't name names, but how many inventors does it take to screw in a light bulb?


APPLY CIRCULAR MOTION
THREAD
TO GET FORCE IN THIS DIRECTION

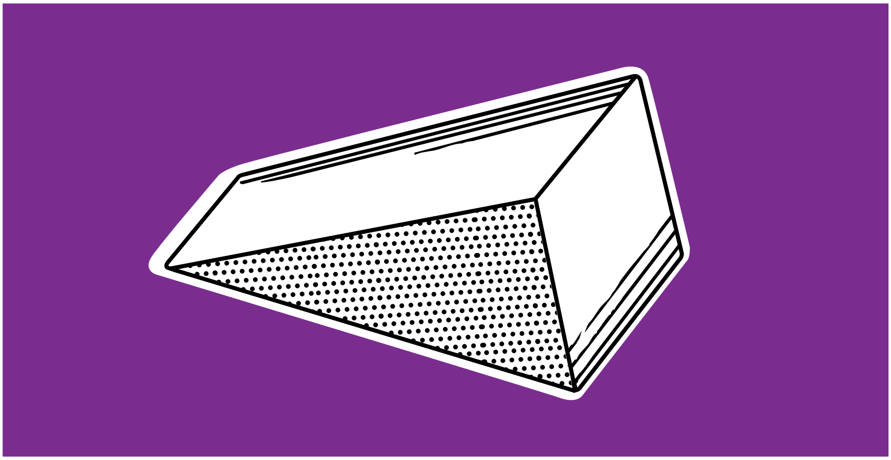
The Wedge

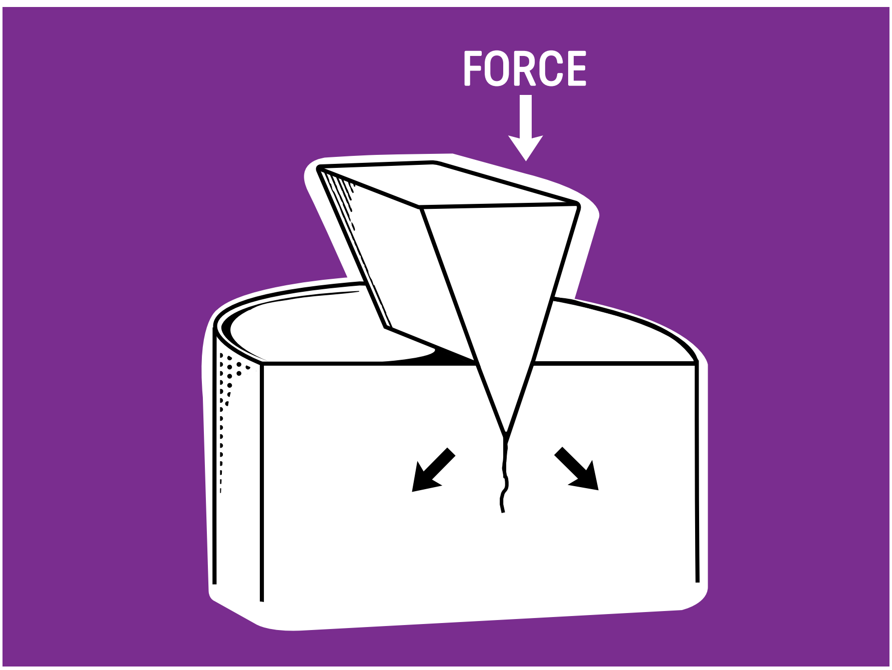
This article is about wedges, not wedgies. If you want to read about wedgies, you'll have to look somewhere else (and also, you're probably a little weird). A wedge is a piece of material (usually hard) with two sloping sides that meet to form an edge (usually sharp). Pound a wedge into something hard enough, and it will split that something apart. The blade of an ax is a good example of a wedge. The two large sides of the blade slope diagonally toward each other until they meet to form the sharp edge.

Like all the simple machines, the wedge offers a mechanical advantage. In other words, it takes whatever effort you put into a task and provides an output that is greater. Imagine, for example, that you are a lumberjack splitting a tree stump with an ax. The wedge shape of the blade turns the force of your swing into an even stronger force once the blade makes contact with the stump.

You can find wedges all over. The pointed ends of a fork are wedges. The slider you pull down to unzip your jacket is a wedge that splits apart the "teeth" of the zipper. And speaking of teeth, you have about ten wedges with you at all times—built right into you, as a matter of fact. Feel the upper and lower teeth near the front of your mouth. (Ms. Lamarr hopes your hands were clean. Otherwise, "Yuck.") Your teeth start out thick near your gums, and then narrow to a sharp edge. Those tiny personal mouth wedges work the same way as an ax blade. The force of your bite causes the sharp edges of your teeth to split apart that delicious Brussels sprout.

Humans were using wedges to split things way back in the **Stone Age**, which makes the wedge one of the first inventions ever. Wedges helped early humans cut wood for fire, hunt (the sharp ends of spears and arrows are wedges), and grow food (the blade of a plow, a very important farming tool, is a wedge). Think about that as you're brushing your mouth wedges tonight.



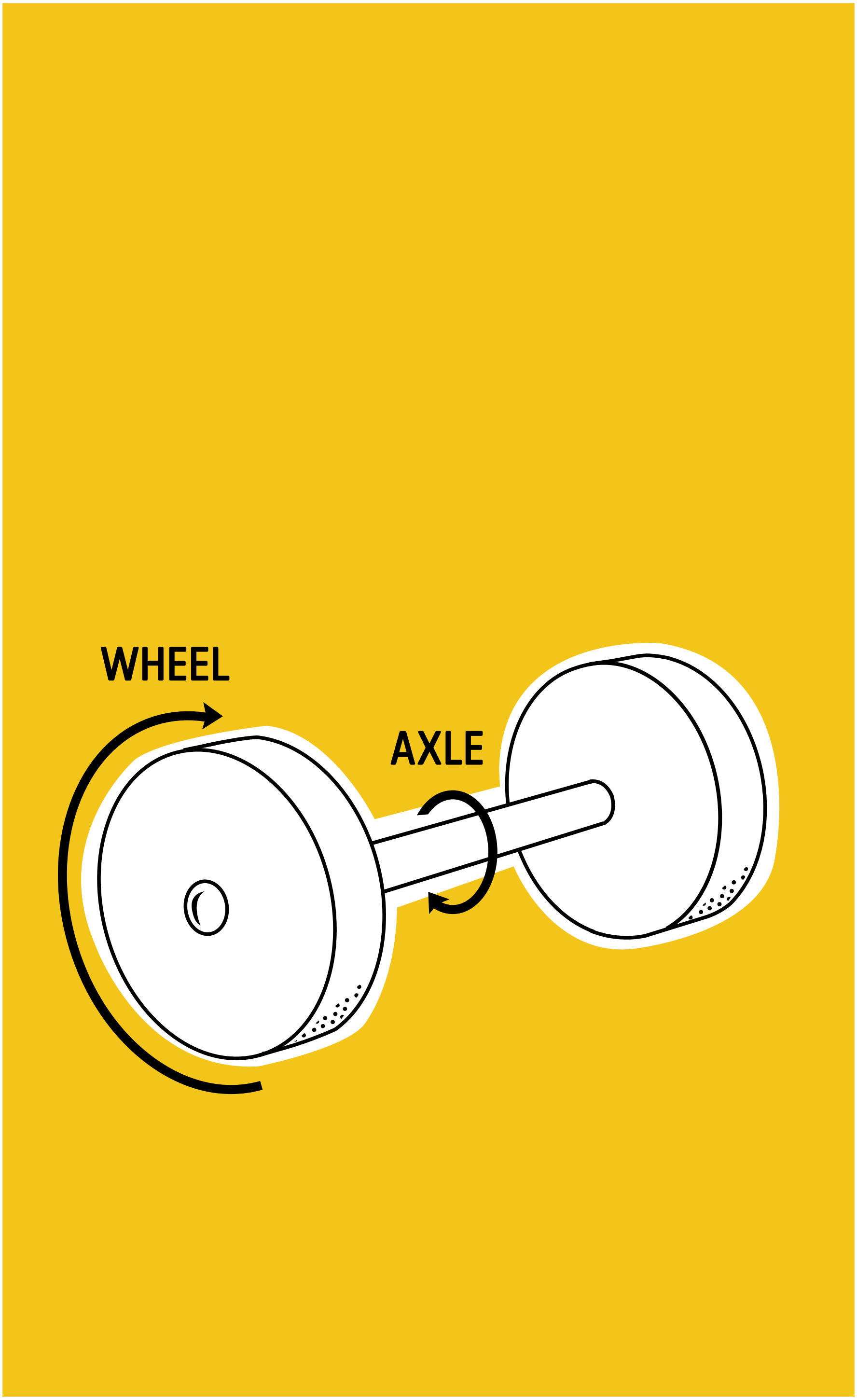


The Wheel and Axle

When you finally have all those invention wedges you're competing for, they are going to form a wheel. Join a wheel with an axle and you're looking at a simple machine that has been a building block for many other machines.

You might think of the wheel as an invention mainly connected with transportation. But wheels can be used for a lot more than moving things from place to place. Attach a long, thin cylinder (an axle) to a wheel and you've got a simple machine that offers a mechanical advantage, helping you accomplish more with less effort. For instance, imagine pulling a bucket full of water up from an old-fashioned well. The bucket hangs from a **cylinder** (the axle) that you turn with a crank (the wheel). You could try raising the bucket by pulling the rope directly or by turning the axle by hand, but either of those methods would require more effort than hoisting the bucket by turning the crank (the wheel).

When Jacques steers his boat, the *Calypso*, he's using a wheel and axle, too. Boats change direction when the rudder, a flat plank attached to the back of a boat, moves left or right. But at sea, a boat's rudder is under water, which means moving it by hand would be a very hard (and wet) job. The wheel and axle make the job easy. A boat's steering wheel (which sailors just call the wheel) is attached to an axle, which is connected by rope to the rudder. With very little effort, Jacques can turn the wheel of his boat, which turns the axle. Then the axle does the hard work of moving the rudder left or right. Let's hope he steers clear of jellyfish.


WHEEL
AXLE

Louis Braille

Bonjour!

Where to start … well, I was born on January 4, 1809, in Coupvray, France, a small town not too far from Paris. When I was a child, my favorite place to play was my father's workshop. Oh, it was ***très magnifique***! He made saddles and harnesses for horses. I'll never forget the wonderful smells and sounds of the leather and the tools. But these simple joys would not last. The entire course of my life changed when I was only three years old. One day, when I was using some of my father's tools, I managed to poke myself in the eye. But this was not just any poke. ***Quelle guigne***! What bad luck—the eye became infected and the infection spread to my other eye. By the age of five I was completely blind. While it made learning more challenging, being blind didn't dampen my desire. As you probably hunger for chocolate or pizza, I hungered to read. Unfortunately, at that time, books for the blind to read by touch were scarce. They featured giant raised letters, but they were very heavy, difficult to produce, and not at all **practical**. Consequently, almost everything I learned from books was read *to* me by my teachers at the school for the blind in Paris.

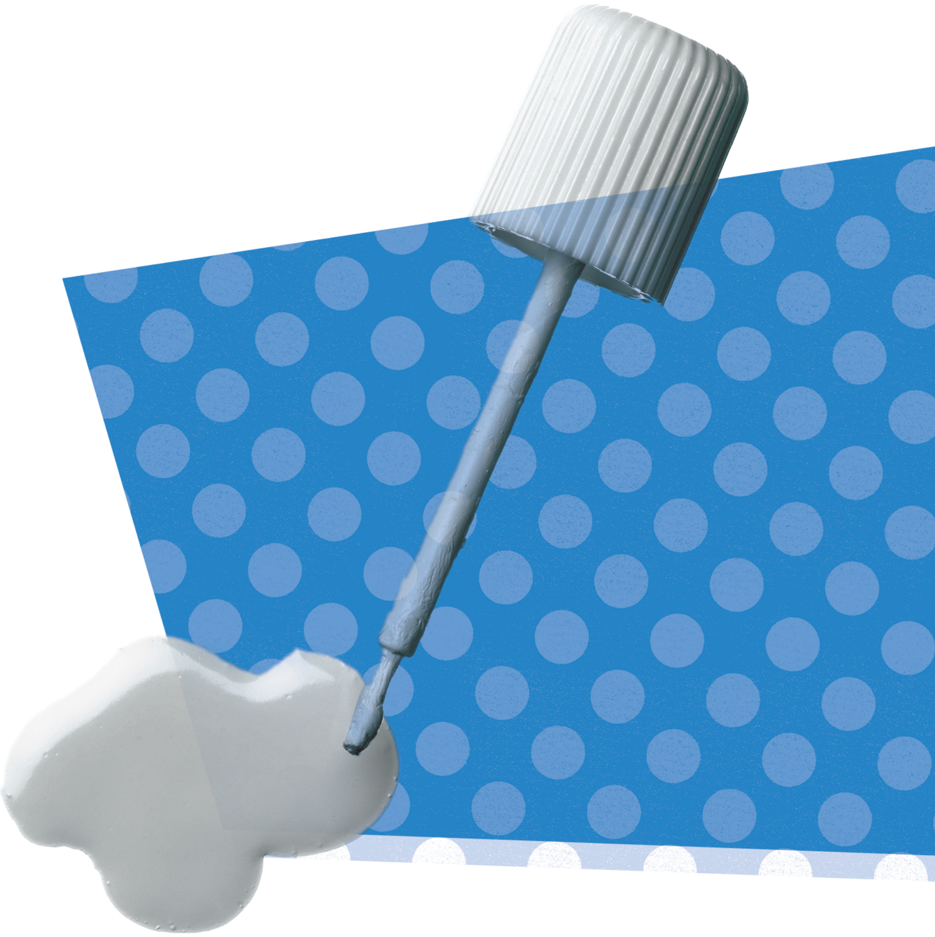
Then, when I was twelve, a French army captain named Charles Barbier visited my school. He told us about *night writing*, a communication system he'd invented for soldiers on the battlefield. Night writing was a complicated code of dots pressed into paper. And I do mean complicated! The system was so hard to learn that the army gave up on it. But it got me thinking … what if there were an alphabet for the blind that could easily be read but didn't have to be written in extra-large letters? And what if blind people could also write in this alphabet without using big, clunky machines?

Transforming night writing into this new alphabet became my mission, and by age fifteen I had done it. In my new system, each letter was represented by a simple arrangement of tiny raised dots. Just as I hoped, my invention allowed full-length books for the blind to be lighter and smaller, so they were much easier to print. And even more importantly, my alphabet was very easy to read by touch, and also gave the blind a practical way to write using only a simple **stylus**. In the years that followed, I added to my invention so that blind people could read and write music and mathematical equations. The *Braille alphabet* caught on, and Braille books have been published all over the world. ***Quelle merveille***! It is incredible, don't you agree?

Bette Nesmith Graham

Howdy, guys and gals. And thank you all so much for the chance to appear on the program. I'm afraid my invention may seem a little old-fashioned today, but in the 1950s it was **revolutionary**. Back then I worked as a secretary at a big bank in Dallas, Texas—which also happens to be the town where I was born on March 23, 1924. Of course, we didn't have computers and printers in those days. All our letters and business documents were typed on typewriters. You've seen typewriters, haven't you? Oh gosh, maybe not—you're all so young! Anyway, we had the darndest time if we typed even one letter wrong. A pencil eraser doesn't work on typewriter ink. No eraser does—believe me, I tried lots of them. The **upshot** was, if you made a mistake, you had to go back to the beginning and start again. Can you imagine?

Then, one December, I was painting holiday snowflakes on the bank windows when it suddenly hit me. Painters don't erase their mistakes; they paint over them. Maybe the same idea would work for fixing typing mistakes! So I mixed up a batch of quick-drying paint that matched the color of the bank's typing paper, and put it in a bottle with a tiny little paintbrush. The next day at work, when I made a mistake in my typing, I just painted over the wrong letters and then typed the correct ones over the paint after it dried. Soon all the secretaries at the bank were asking for my magical Mistake-Out. A chemistry teacher at the local high school helped me improve the formula, and all of a sudden I was selling my invention—now called Liquid Paper—all over the world. I ran my own company, bringing a rarely seen feminine touch to the business world: for instance, it was almost unheard of in the 1970s for a company to have a child care center, as mine did. I was unstoppable and one of the most successful women in business (My company sold for nearly fifty million dollars in 1979!). So you little pups should really keep your eyes open for problems to solve, and keep your minds open for all kinds of different ways to solve them. You never know what you'll think up!



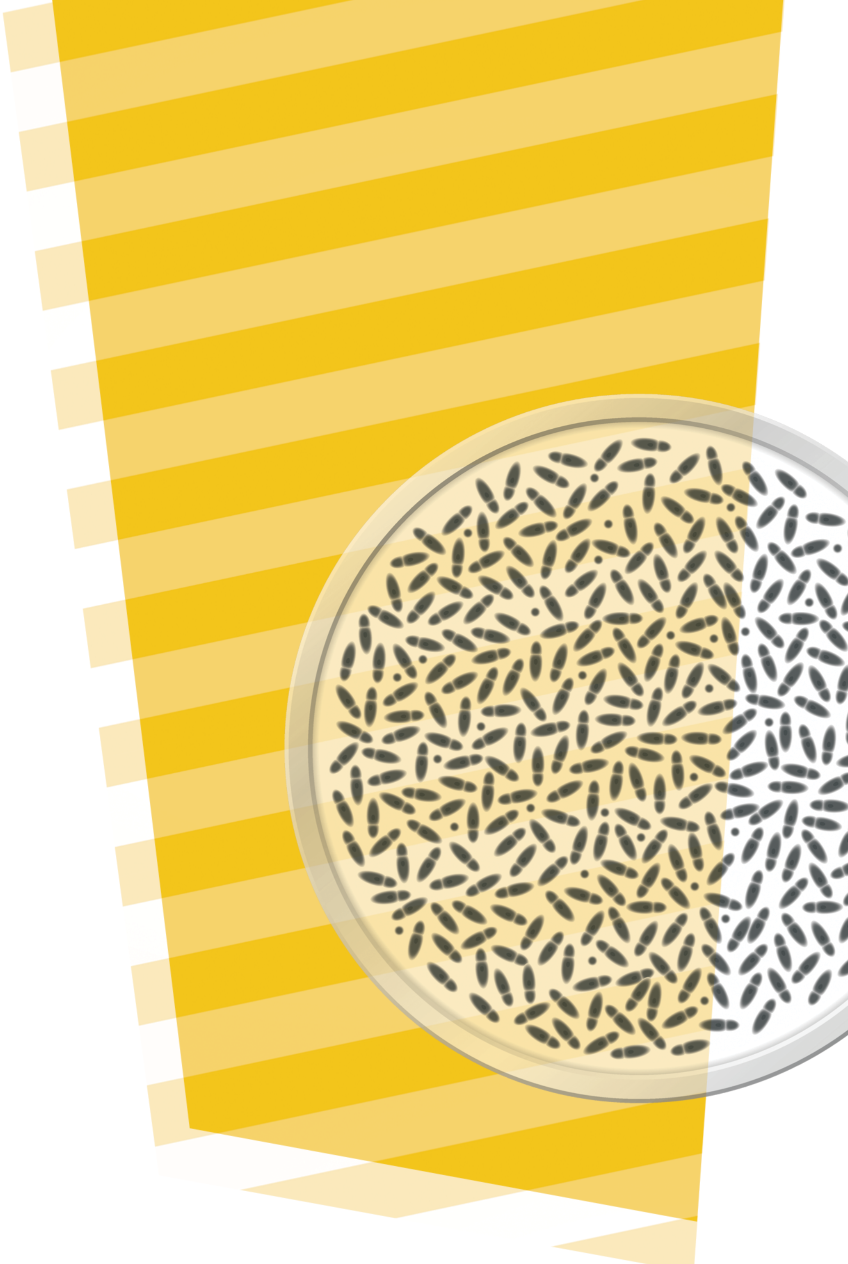
Alexander Fleming

Hello and good day to you, student inventors! It's a pleasure to be on the show. My name is Alexander Fleming—well, Sir Alexander Fleming, as of the day I was knighted by King George VI in 1944. But I'm getting ahead of myself. I was born on August 6, 1881, on a farm in Ayrshire, Scotland. But I wasn't meant for farm life. I moved to London as a young man and became a **bacteriologist**—a scientist who conducts experiments on bacteria. During World War I, I served as a captain in the Royal Army Medical Corps. There I saw too many men die needlessly in field hospitals, where I suspected the **antiseptics** used to clean their infected wounds were more dangerous than the wounds themselves. But no one **heeded** my warnings and the antiseptics continued to be used—it was, to say the least, a frustrating time for me.

After the war I was busy at St Mary's Hospital in London, studying a particularly nasty bacterium called staphylococcus that causes **boils**, **abscesses**, and sore throats. I had a very good reputation amongst those studying bacteria, though I was known to be a little sloppy—OK, very sloppy—in my lab. I admit it: being orderly isn't my strength. You can't imagine the trouble this got me into growing up on the farm—I mean,

do you know how angry a cow gets when you forget to milk her? But I **digress**. On September 3, 1928, I returned from a lengthy family holiday to find that I'd left a stack of **petri dishes** filled with live bacteria **cultures** sitting out on a bench (needless to say, this is not where cultures ought to be left, even for a night or two!). Unsurprisingly, one of the cultures had become **contaminated**—invaded—by a fungus, a kind of mold. But surprisingly, the fungus seemed to be preventing the bacteria from growing around it. This was curious. So I decided to grow the fungus, which I called penicillin, again, and realized that it successfully killed bacteria!

This was great, but I still didn't comprehend the huge import of what I'd discovered. What can I say? We can't always see precisely what we have when we have it. After all, I tested penicillin for a number of years, but came to the conclusion that it couldn't survive long enough within the human body to fight infection successfully, and I moved on. Luckily, other scientists stuck with it. By the end of World War II, penicillin was saving many soldiers' lives. And shortly thereafter I became Sir Alexander Fleming and shared the Nobel Prize in medicine. Penicillin was the first **antibiotic** and it unquestionably changed the world. It is widely considered one of the most important inventions of the twentieth century. The moral of the story? I think I'd put it something like this: "One sometimes finds what one is not looking for. When I woke up just after dawn on [that day in September, 1928], I certainly didn't plan to revolutionize all medicine by discovering the world's first antibiotic, or bacteria killer. But I guess that was exactly what I did."



Glossary

A

abscesses, ***n:*** inflammations caused by bacteria

agricultural, ***adj:*** relating to farming

airborne, ***adj:*** in flight

antibiotic, ***n:*** a medicine that kills or stops the growth of diseased cells

antiseptics, ***n:*** substances that prevent the growth of disease-causing microorganisms

aquatic, ***adj:*** relating to water

arguably, ***adv:*** able to be supported by a reasonable argument

avid, ***adj:*** eager or excited

B

baboon, ***n:*** a kind of monkey

bacteriologist, ***n:*** a scientist who studies microscopic organisms that often cause disease

bigwigs, ***n:*** important people

boils, ***n:*** a painful skin condition

botanist, ***n:*** a scientist who studies plants

botany, ***n:*** the scientific study of plants

C

charred, ***adj:*** burnt

contaminated, ***adj:*** harmful or unusable due to contact with something unclean

crop rotation, ***n:*** yearly switching of which crops are grown on a piece of land

cultures, ***n:*** growths of microorganisms in a nutrient medium

cylinder, ***n:*** an object with identical flat ends and a circular or oval section

D

deliberately, ***adv:*** on purpose

deter, ***v:*** discourage

diaphragm, ***n:*** a thin disk or piece of material that vibrates when producing or receiving sound waves

digress, ***v:*** get off the subject

dim, ***adj:*** not bright

drawbacks, ***n:*** disadvantages, problems

E

ecosystems, ***n:*** systems formed by the interaction of communities of organisms with their environments

English Channel, ***n:*** a body of water separating England and France

evaporate, ***v:*** change from a liquid state into a vapor

F

fertile, ***adj:*** capable of producing healthy plants

financiers, ***n:*** people who give inventors money to develop and sell their products, in return for a portion of the profits

frequency, ***n:*** the rate at which radio signals are transmitted

G

greasy spoons, ***n:*** slang for cheap and unsanitary restaurants

H

heed, ***v:*** pay attention to

humble, ***adj:*** not significant; modest

I

illumination, ***n:*** brightness

indifference, ***n:*** lack of interest

inspire, ***adj:*** give rise to, lead to

intricate, ***adj:*** detailed, complicated

inventory, ***n:*** a complete list

irk, ***v:*** bother, irritate

irritation, ***n:*** the state of being annoyed

isolated, ***adj:*** far away from other places, buildings, or people; remote

M

malfunctioning, ***adj:*** not working properly

manure, ***n:*** a substance made from animal poop that is spread on plants to help them grow

marketing, ***n:*** activities involved in advertising and selling a product

O

optimistic, ***adj:*** expecting a favorable outcome

organisms, ***n:*** living things

P

parchment, ***n:*** animal skin prepared for use as a writing surface

patent, ***v:*** get a government license giving an inventor the right to be the only one to manufacture and sell their invention for a certain period of time

pendulum, ***n:*** a weighted, swinging lever that regulates the speed of a clock

petri dishes, ***n:*** shallow, circular, transparent dishes with flat lids, used for the culturing of microorganisms

phonograph, ***n:*** a machine that reproduces sound by means of a needle in contact with a grooved rotating disk

player piano, ***n:*** a piano fitted with an apparatus enabling it to be played automatically

potential, ***n:*** qualities or abilities that may be developed and lead to future success

practical, ***adj:*** useful

prestigious, ***adj:*** highly respected

primates, ***n:*** a category of mammals that includes humans, monkeys, and apes

producers, ***n:*** people who supervise a television production

profit, ***n:*** (often financial) gain

Q

quelle guigne, French for "what bad luck!"

quelle merveille, French for "how marvelous!"

R

rehabilitation, ***n:*** recovery

revolutionary, ***adj:*** bringing about major change

S

self-sufficient, ***adj:*** able to take care of oneself

sharecroppers, ***n:*** farmers who had to give part of their crop away as rent

simians, ***n:*** monkeys

spearhead, ***v:*** lead

Stone Age, ***n:*** a period in the history of mankind marked by the use of tools and weapons made of stone

stylus, ***n:*** a pointed, pen-shaped instrument used to make an imprint on a surface

sundial, ***n:*** an instrument showing the time with the shadow of a pointer cast by the sun onto a plate marked with the hours of the day

synchronized, ***adj:*** occurring at the same time

T

take root, ***v:*** begin

telegraph, ***n:*** a machine that transmitted and received messages across great distances using electrical signals and wires. Messages were transmitted in codes that had to be received and translated by specially trained operators

tinker, ***v:*** to work at something

transmitter, ***n:*** a set of equipment used to generate and transmit electromagnetic waves carrying messages or signals, especially those of radio or television

très magnifique, ***adj:*** French for "really wonderful"

U

upshot, ***n:*** result

V

vaccines, ***n:*** medicines to make people immune to diseases

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