Code Project Resources

Project Based Learning- How do codes affect our lives and the ways we communicate?

The following resources can be used to help guide the discovery of codes in our world.

Online Resources

- [https://scratch.mit.edu/](https://scratch.mit.edu/) - Students can share games and animations that they create on the site using simple coding language.

- [https://blockly.games/](https://blockly.games/) Web based coding games that use colorful blocks and introduce proper terminology

- [https://www.apple.com/swift/playgrounds/](https://www.apple.com/swift/playgrounds/) Apple's coding language. Lessons are structured like puzzles to be solved and help students move from drag and drop to word based programming


- [https://code.org/](https://code.org/) Learn to code with tutorials and free activities.

- [http://www.alice.org/](http://www.alice.org/) Alice is an innovative block-based programming environment that makes it easy to create animations, build interactive narratives, or program simple games in 3D.


- [http://www.designhistory.org/Symbols_pages/symbols.html](http://www.designhistory.org/Symbols_pages/symbols.html) Examples of symbols and codes used in design. What do all of these different symbols and codes mean?

- [https://www.cia.gov/kids-page](https://www.cia.gov/kids-page) Explore the CIA kids page to discover how the CIA uses codes

Code Videos:

- How does Morse Code work?:
  - [https://youtu.be/iyB8aMs_JUl](https://youtu.be/iyB8aMs_JUl)

- Tedx Talk- Coding: By a kid, for kids:
  - [https://youtu.be/vOsdfRbrNdk](https://youtu.be/vOsdfRbrNdk)
Code Project Resources

Project Based Learning - How do codes affect our lives and the ways we communicate?

Printed Leveled Readings

- Code Communication
- Computer Programmers
- Code Talkers
- Code Crackers
- Grace Murray Hopper Biography
- Frida Kahlo Biography
- Mysterious Mayan Writing
- Speaking in Code

Articles For Parents and Caregivers

- Education World: Welcoming Family Diversity in the Classroom:
- Edutopia: How Teachers Can Support PBL at Home:
  - [https://www.edutopia.org/article/how-teachers-can-support-pbl-home](https://www.edutopia.org/article/how-teachers-can-support-pbl-home)
- Edutopia: Strategies for Differentiated Instruction in Project Based Learning:
  - [https://www.edutopia.org/blog/differentiated-instruction-strategies-pbl-andrew-miller](https://www.edutopia.org/blog/differentiated-instruction-strategies-pbl-andrew-miller)
Lesson 19
Understanding Supporting Evidence

Learning Target
Understanding the reasons and evidence an author uses to support points will help you better understand a text.

Read  When reading informational texts, look for the points the author presents to convince you an idea is true. To figure out whether an author's points are supported, look for any reasons and evidence he or she supplies for each point. A reason is an explanation for why the idea might be true. A piece of evidence is a fact that can be proven true.

In the comic strip below, identify the reasons and evidence the girl gives for needing a secret code.

Hey, wanna go outside?  Can't. I'm developing a code for secret messages.

Well, my diary keeps moving around my room...  I keep finding it open...

Why do you need that?  It's my brother. He keeps reading my diary.

It's not a problem. He does? What's your evidence?

and he keeps telling me to write more neatly.

Only if it's not a problem.
**Think**  What have you learned about points, reasons, and evidence?  
Complete the chart below for the comic strip on the previous page.

<table>
<thead>
<tr>
<th>What Does the Girl Think?</th>
<th>Why Does She Think This?</th>
<th>What Evidence Supports Her Thinking?</th>
</tr>
</thead>
<tbody>
<tr>
<td>She needs a code.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Talk**  Share your chart with a partner.
- What does the girl think?
- Why does she think what she thinks?
- What evidence supports her thinking?

**Academic Talk**
Use these words to talk about the text.
- **points**
- **reason**
- **evidence**
1. Secret codes and power go hand-in-hand. Why is this so? Because a code lets one group of people communicate information in a way that keeps it secret from other groups. The group that knows the code has an advantage over the group that doesn’t.

2. Take the example of Julius Caesar, an emperor of ancient Rome who conquered much of Europe and northern Africa. Caesar used letters to communicate his military plans to faraway generals. But what if an opposing army obtained copies of his letters? His plans might be foiled. So Caesar developed a code that only he and trusted members of his army understood. If an enemy intercepted Caesar’s letters, they would not understand them or be able to prepare for his plans. The code gave Caesar an advantage over his opponents, letting him keep and increase his power.

3. Not all codes were as successful as Caesar’s, however. In the 1500s, when Elizabeth I was Queen of England, her half-sister Mary plotted to overthrow her. Mary communicated with her allies through coded messages. However, Mary’s code was easy to crack, so her plan was discovered. If Mary had used a better code, she might have risen to power as the Queen of England.

4. Codes remain important in modern times. During World War II (1939–1945), German submarines communicated in code so complicated that it was nearly unbreakable. But a brilliant Englishman named Alan Turing cracked the German code. Now that the English knew when and where a British ship would be targeted, they could fight back. When the Germans’ code was broken, they lost a powerful advantage.

5. Secret codes aren’t just about power, of course. It’s fun to develop a code to communicate secrets. But when rulers and armies use codes, they’re not doing so for fun. For them, it’s serious business.
What reasons and evidence does the author use to support his idea about codes?

Think

1. The author states, “Secret codes and power go hand-in-hand.” Complete the chart to explain why the author thinks this and describe three pieces of evidence supporting his thinking.

<table>
<thead>
<tr>
<th>What Does the Author Think?</th>
<th>Why Does He Think This?</th>
<th>What Evidence Supports His Thinking?</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Secret codes and power go hand-in-hand.”</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

Talk

2. How does the author support his idea about secret codes? If necessary, revise the second and third columns of your chart.

Write

3. **Short Response** The author states that a group with a secret code has an advantage over groups that do not. Explain how the author supports this idea. Use details from the passage in your response. Use the space provided on page 342 to write your answer.

**HINT** Use phrases such as “one example” and “a second example” to organize your response.
Back in the 1990s, an intriguing idea arose. People began claiming that during the American Civil War, 1861–1865, African slaves in the southern states used a secret code to help one another escape north to freedom.

This code consisted of patterns sewn into quilt blocks by slave women. For example, a pattern called wagon wheel meant to quickly load up a wagon and prepare to head north. And a pattern called shoo-fly signaled that a friendly guide waited nearby to help. Such quilts helped runaway slaves make their way along a network of routes known as the Underground Railroad to freedom.

Films and books sprang up about how these bedcovers with their secret messages sewn by slave women saved lives and led enslaved people to freedom. The popular Oprah Winfrey TV show even featured these claims and stories. The public loved these thrilling accounts of adventures from America's past.

But wait. How true were they? These quilt code accounts were exciting, yes, and people wanted them to be historically accurate. But were they?

Many historians have studied slavery and the Underground Railroad. These historians reviewed the evidence. None of it appeared to come directly from the slaves, they concluded. There were no letters and no news articles quoting the slaves themselves. It all came from stories passed along by word of mouth. And none of the quilts used to help runaway slaves could be found.

Still, many books were written concerning these oral accounts, exciting stories of secret hiding places, life-threatening encounters, and midnight escapes. But there were no documents to back up these quilt code claims. Based on the lack of strong evidence, we must conclude that quilts played no special role in the Underground Railroad.

How does the author support the idea that quilts played no special role in the Underground Railroad? Underline any information supporting this idea.
Think

Use what you learned from reading the article to answer the following questions.

1 This question has two parts. Answer Part A. Then answer Part B.

Part A
How does the author support the idea that people wanted to believe African slaves in the South used a secret code?

A by showing that the history of the quilt code wasn’t known before the 1990s, and then it became a popular topic
B by showing that experts believe the quilts’ patterns had different meanings and gave signals to escaping slaves
C by showing that the slave quilt codes were related to the Underground Railroad, which is an interesting topic
D by showing that the stories about the quilt codes were the subjects of popular books, films, and shows

Part B
Which detail from the article supports the answer in Part A?

A “The popular Oprah Winfrey TV show even featured these claims. . . .”
B “Many historians have studied slavery and the Underground Railroad.”
C “It all came from stories passed along by word of mouth. . . .”
D “… there were no documents to back up these quilt code claims.”

Talk

2 The author states that quilts with secret messages played no part in helping enslaved people escape to the North. How does the author support this idea? Use the chart on page 343 to record your ideas and the evidence.

Write

3 Short Response How does the author support the idea about quilts not having secret messages? Provide two examples of the evidence the author uses to support the idea. Use the space provided on page 343 to write your answer.

HINT Start by restating the author’s conclusion. Then tell how he supports it.
Write  Use the space below to write your answer to the question on page 339.

The Power of Codes

3 Short Response The author states that a group with a secret code has an advantage over groups that do not. Explain how the author supports this idea. Use details from the passage in your response.

Check Your Writing

☐ Did you read the prompt carefully?
☐ Did you put the prompt in your own words?
☐ Did you use the best evidence from the text to support your ideas?
☐ Are your ideas clearly organized?
☐ Did you write in clear and complete sentences?
☐ Did you check your spelling and punctuation?
2 Use the chart below to organize your ideas and evidence.

<table>
<thead>
<tr>
<th>What Does the Author Think?</th>
<th>Why Does He Think This?</th>
<th>What Evidence Supports His Thinking?</th>
</tr>
</thead>
</table>

3 Write Use the space below to write your answer to the question on page 341.

**Short Response** How does the author support the idea about quilts not having secret messages? Provide two examples of the evidence the author uses to support the idea.

**HINT** Start by restating the author's conclusion. Then tell how he supports it.
On the sands of Iwo Jima island, any other World War II code machine would have been too slow to use in the heat of battle. But the Marines had highly mobile cryptographs, each with two arms, two legs, and an unbreakable code. . . .

Naastosi Thanzie Dibeh Shida Dahnestsu Tkin Shush Wollachee Moasi Lin Achi.

Ordinary Marines listening to this babble were as baffled as Japanese soldiers intercepting the messages. Had they spoken Navajo, they would have recognized the words — “Mouse Turkey Sheep Uncle Ram Ice Bear Ant Cat Horse Intestines.”

But what could such nonsense mean? To the Navajo Code Talkers, the first letter of each word spelled out Mt. Suribachi. Other code filled in the announcement: Iwo Jima was under American control.

The Navajo Code Talkers were unique in cryptographic history. From 1942 to 1945, more than 400 Code Talkers stormed the beaches of Pacific islands. Instantly encoding and decoding messages, they helped Marines win the war in the Pacific. Even today, their code remains one of the few in history that was never broken.

1 cryptographs: code-makers
When World War II began, hundreds of Navajo men volunteered to fight. Most had never been off their reservation, a high, barren plain stretching across Arizona, Utah, and New Mexico. There they lived as a separate nation, as many still do today. The reservation had no electricity or indoor plumbing, and only a few schools. Most Navaho herded sheep and bought from government trading posts what little they needed and could not make. They spoke some English, but the business of their daily lives was conducted in their own language.

Among languages that were spoken by only tens of thousands of Americans, Navajo was the language least likely to be known to foreigners. The language was entirely oral. Not a single book had ever been written in Navajo. . . .

The Navajo code was proposed by a non-Navajo, Philip Johnston, the son of missionaries on the reservation. Marine officers were skeptical at first. American armies had used other Indian languages to send messages during World War I. Yet because the ancient dialects had no words for machine gun or tank, the experiment failed. Johnston had a better idea—a language combined with a code. . . .
**Making a Code**

9 The Navajo language contained no words for the horrors of war. Bomber, battleship, grenade—all were terms foreign to the Navajo. But in making their code, the Navajo soldiers rooted it, like their lives, in nature. They named military planes after birds. *Gini*, Navajo for “chicken hawk,” became “dive bomber.” *Neasjah*, meaning “owl,” meant “observation plane.” They named ships after fish. *Lotso*, meaning “whale,” was the code word for “battleship,” and *beshlo*—“iron fish”—meant “submarine.”

10 To spell out proper names, the Code Talkers encoded a Navajo zoo. Marines spell out abbreviations with their own alphabet, which begins Able, Baker, Charlie . . . The Navajo version began *Wollachee, Shush, Moasi*, meaning Ant, Bear, Cat.

11 Finally, Code Talkers created clever terms for friends and enemies. Lieutenant was translated as “One Silver Bar.” Mussolini, Italy’s fascist dictator, was *Adee-yaats-tin-Tsoh*—“Big Gourd Chin.” Hitler became *Daghailchiih*—“Moustache Smeller.”

**Test Time**

12 With just 400 words encoded, the Navajo put their cryptology to the acid test. They handed a message to Navy intelligence officers, who spent three weeks trying and failing to decipher it. Then, armed with a code and M-1 rifles, a few dozen Code Talkers shipped out to the Pacific. Two more remained behind to teach the code to other Navajo recruits. . . .

13 Between invasions, the Code Talkers convened² to encode new battle terms. Before the war ended, several were killed in action. Yet they transmitted thousands of messages without error. In a language that needs no decoding, Marine major Howard Conner assessed their contribution. “Without the Navajos,” Conner said, “the Marines would never have taken Iwo Jima.”

² *convoked*: gathered
Think  Use what you learned from reading the history article to answer the following questions.

1  This question has two parts. First, answer Part A. Then answer Part B.

Part A
How does the author support the idea that the Navajo men who volunteered to fight in World War II had been living isolated lives?
A  by stating that their messages were impossible to understand
B  by stating that most had never been off their reservation
C  by stating that they communicated orally and not in writing
D  by stating that they named planes and boats after animals

Part B
Which paragraph in the text best supports the answer to Part A?
A  paragraph 3
B  paragraph 5
C  paragraph 6
D  paragraph 9

2  The author uses a word that means “doubtful” in the text. Circle a word in the paragraph that best represents that idea.

The Navajo code was proposed by a non-Nativo, Philip Johnston, the son of missionaries on the reservation. Marine officers were skeptical at first. American armies had used other Indian languages to send messages during World War I. Yet because the ancient dialects had no words for machine gun or tank, the experiment failed. Johnston had a better idea—a language combined with a code. . . .
3 This question has two parts. First, answer Part A. Then answer Part B.

**Part A**
How does the author support the idea that the Navajo soldiers were able to make a code related to war even though their language lacked words for it?

A by showing how they mixed language and culture in the code  
B by showing that they started by encoding 400 words  
C by showing how they proved the Navy couldn’t break the code  
D by showing that they met several times to encode new terms

**Part B**
Which two details from the article support the answer in Part A?

A “…the business of their daily lives was conducted in their own language.”  
B “…Navajo was the language least likely to be known to foreigners.”  
C “…the Navajo soldiers rooted it, like their lives, in nature.”  
D “Lotso, meaning ‘whale,’ was the code word for ‘battleship’…”  
E “Marines spell out abbreviations with their own alphabet…”  
F “…remained behind to teach the code…”

4 Which of the following best supports the idea that the Navajo code was hard to crack?

A “…the first letter of each word spelled out Mt. Suribachi.”  
B “The Navajo Code Talkers were unique in cryptographic history.”  
C “Even today, their code remains one of the few in history that was never broken.”  
D “The Navajo language contained no words for the horrors of war.”
Write

5 Short Response The author states that the Navajo Code Talkers helped win the war in the Pacific. Explain how the author supports this idea. Use at least two details in your answer.

________________________________________________________________________

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Learning Target

In this lesson, you explained how an author uses reasons and evidence to support points. Explain how this work will help you better understand other informational texts that you read.

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________________________________________________________________________
Computers and Programmers
6 Articles

Check articles you have read:

☐ Samuel F. B. Morse (1791-1872) 415 words

☐ Women Programmers of ENIAC 451 words

☐ Grace Hopper (1906-1992) 752 words

☐ Thomas A. Edison (1847-1931) 448 words

☐ Life Story: Herman Hollerith (1860-1929) 644 words

☐ Watson on Jeopardy! 452 words
Samuel F. B. Morse (1791-1872)

This text is provided courtesy of the New-York Historical Society.

In the 1740s, a French clergyman and physicist named Jean-Antoine Nollet discovered that an electrical current moved along a wire so fast, it was almost instantaneous. For the next decades, scientists and inventors looked for a way to use this finding to send electrical messages along a wire, almost instantaneously. No one succeeded. The French finally gave up, and in 1794, built the French State Telegraph, which involved observers with telescopes standing in towers and relaying visual signals from one to the next. It was faster than a messenger on a swift horse, and it introduced the word "telegraph," but it was not the electrical system many inventors still pursued in Europe and the United States. And it only worked in clear daylight.

Samuel F. B. Morse was a painter and inventor who grew up in New England and moved to New York City in the 1820s. Like many others, he was fascinated by the idea of an electrical telegraph. He began sketching designs in 1832, around the time he returned to New York after a trip to Europe. He worked alone at first, then with two important partners. One was NYU chemistry professor Leonard Gale, who suggested Morse replace the single large battery in his design with several small ones.
spaced out along the wire. This was crucial for sending a signal over a long distance, because electricity weakens as it travels, a problem Morse and his competitors all faced. And Morse's business partner, Alfred Vail, helped create the Morse code, which converted letters and numbers into long and short electrical pulses, also known as dashes and dots.

In addition to the code, Morse designed the equipment that sent, transmitted, and received the signal. In 1838, he and his team sent a message across two miles near Morristown, New Jersey. In 1844, Morse was able to transmit his famous phrase, "What hath God wrought," from Washington, D.C., to Baltimore. And by 1850, twenty different companies ran some 12,000 miles of telegraph lines in the U.S. The days of sending a messenger on a galloping horse were mostly over.

In England, William Fothergill Cooke and Charles Wheatstone designed their own workable telegraph, with its own language. But Morse code dominated and became the accepted international language of telegraphy. It was the ancestor of modern computer code, using dots and dashes the way computer software uses 1s and 0s to transmit data.
Women Programmers of ENIAC

This text has been provided courtesy of the New-York Historical Society.

Rosie the Riveter was a World War II nickname for women who worked in factories and shipyards all across the country. The two women in this photo were not like Rosie. They, and four others, were working on a machine at the University of Pennsylvania, called ENIAC (Electronic Numerical Integrator and Computer). It was designed to do complex calculations related to ballistics and the correct aiming of a weapon, but the war ended before ENIAC was functional.

Work on it continued, however. This photo, taken around 1946, shows only a portion of the room-sized computer. It was completely electronic, so it should have been far faster than the other big war-time calculator, the Mark I, developed by IBM and programmed at Harvard by Grace Hopper and others. The Mark I was electromechanical, which means it was driven by electricity but had mechanical moving parts that slowed it down. The Mark I's instructions could be stored on a paper tape, however, which gave it a big advantage. In ENIAC, by contrast, every calculation involved plugging cables into a board, as Marilyn Melzer (crouching) is doing here. Ruth Lichterman (standing) is holding a diagram of the machine's wiring.

To program ENIAC, the women had to first analyze the hundreds of differential equations involved in a particular calculation. Then, they used the diagrams and blueprints to determine which cables should go to which plugs, so the machine would do the right steps in the right sequence. They understood both the mathematics and the machine. One of the programmers said later: "The biggest advantage of learning the ENIAC from the diagrams was that we began to understand what it could and could not do. As a result we could diagnose troubles almost down to the individual vacuum tube." There were 18,000 of those tubes, so this was no small feat.

Programming was in its infancy in the 1940s; in fact, the term, "to program," came from the ENIAC team. Women held many of these early jobs. The six ENIAC programmers had been selected from a pool of women with degrees in mathematics who worked on other large-scale calculators during the war. Today, computer jobs are dominated by men. Women's participation in technology has actually decreased in recent years. They hold only a quarter of the tech jobs in the United States, though they account for half the workforce. Only 18 percent of computer science graduates today are women. Often the explanation is that girls don't like math, or don't excel at it, but the experience of these earlier women proves otherwise.
Grace Hopper was born Grace Murray, the first child of a well-off New York City family that encouraged her to explore, even when it meant she was taking apart alarm clocks. Years later, she reminisced about her childhood world: "ancestors who had been scientists and engineers, and my mother's very great interest in mathematics and my father's, a house full of books, a constant interest in learning, an early interest in reading, an insatiable curiosity."

At 18, she left for Vassar College. She graduated with a degree in mathematics, and went on to graduate school at Yale, earning her master's degree in 1930, the same year she married Vincent Hopper. In 1934, she became the first woman to earn a Ph.D. in math from Yale. She then joined the faculty at Vassar, where she shook things up. She scrapped old textbooks, demanded good writing from her math students, and broadened the curriculum with the revolutionary physics she called "the Einstein stuff." World War II changed her life completely. She took a leave from Vassar, and in 1943, joined the WAVES (Women Accepted for Volunteer Emergency Service), a division of the U.S. Navy. Some may have found military life constraining, but she felt liberated from all sorts of minor decisions-what clothes to wear, what to cook for dinner. "I had the most complete freedom I'd ever had."

In 1944, Lieutenant (junior grade) Grace Hopper was sent to Harvard University to work on the Automatic Sequence Controlled Calculator, which had been designed and built by IBM and nicknamed the Mark I. Hopper called it an "impressive beast." It was 8 feet high, 51 feet long, 3 feet deep, and weighed almost 10,000 pounds. The word "programmer" wasn't yet in use, but that was the task she tackled with two colleagues. They did complex calculations related to the war effort, including the design of the atomic bomb. She was the only woman on the team.

Later, she made the work sound easy: "You simply step by step told the computer what to do. Get this number and add it to that number and put the answer there." She had a deep understanding of the machine itself, not only the Mark I but its successors. Once, doing a repair on the Mark II, she found a moth in one of the relays. She taped it into the logbook, and wrote "first actual case of bug being found." "Bug" already meant "problem" in other fields, but thanks to Hopper, it became part of everyday computer talk.

Newly divorced after the war, Hopper worked at Eckert-Mauchly Computer Corporation, later purchased by Remington Rand, then renamed Sperry Rand. As a senior programmer for their UNIVAC computer, she wrote a program called a compiler in 1952. It stored certain commands in the
machine and made operations faster. She had to sell the idea, prove to skeptical colleagues that it worked.

Hopper's compiler paved the way for programming languages that allow human operators to tell computers what to do, and how. In 1957, IBM released FORTRAN (FORmula TRANslation), a language for its 704 Data Processing System. Designed for math, science, and engineering programs, FORTRAN was easy to learn and use, even by people with no previous computer knowledge. Not long after, a group including Grace Hopper began work on a language that could be used by different kinds of businesses and on a variety of computers. Introduced in 1959, COBOL (COmmon Business Oriented Language) became the most widely used computer program in the world.

Grace Hopper was a pioneer in the history of computers, thanks to her upbringing, intelligence, and education. She had a remarkable ability to explain complex ideas, either to a highly technical audience, or to ordinary people. It no doubt helped that she had the right skills at the right time, and that she was blunt, self-confident, and witty. For all these reasons, she rose to the top in a man's world. She knew the men around her sometimes bristled at her presence, including her commander on the Harvard Mark projects, Howard Aiken. But she tended to win over the doubters with her abilities, and she thought the Navy protected her from sexism she might have encountered in civilian life. She left the WAVES after the war, but was recalled to active duty twenty years later, eventually retiring at age 80 as Rear Admiral Grace Hopper. She was highly respected in the Navy, and in the computer world.
His teachers said he was a problem—too bouncy, too many questions about how things work. So after only three months of official schooling, Thomas Edison’s mother decided to teach him at home. She introduced him to science, which became his passion, though many of his experiments ended badly. Move your lab to the basement, his parents said, after yet another explosion shook his room.

Edison had a lifelong fascination with the telegraph, eventually nicknaming two of his children Dot and Dash, after the signals used in Morse code. As a child, Edison tried to build a telegraph of his own. At 16, he started working as a telegraph operator. He was quite deaf from childhood illnesses, but he could hear the clicks of the receiver. At the same time, he was working on several inventions and applying for patents. The boy who asked too many questions had become a young man who deeply understood how things work. By age 21, he had his own engineering firm and was in charge of all equipment owned by Western Union. This major telegraph company also asked Edison to improve on Alexander Graham Bell’s initial design for a telephone, which Bell had invented in his search for a better telegraph.
Edison's headquarters were located in Menlo Park, New Jersey, about thirty miles from New York City. Over time it became a big operation, with laboratory space, a factory, and staff. It was here that Edison invented the phonograph, the incandescent light bulb, and the movie camera, among many other devices. In a golden age of invention, Edison stood out. He helped create and define what we mean by modern life.

Edison's contribution to computer history came not from one of his inventions, but from a scientific discovery. In 1880, while working on his light bulb design, he observed that electrical current could flow through a vacuum, an enclosed space that contains no gas or other matter. In other words, electricity did not need a wire. He used this observation, later dubbed the "Edison effect," to patent a voltage regulator, a device that controls the amount of electric current flowing through a piece of equipment. Some thirty years later, physicist John Fleming realized that if a vacuum could control electrical flow, it could also turn it on and off, like a switch. He invented the vacuum tube, which was used in many early electronics, including radios and televisions. Starting in the 1940s, vacuum tubes were used by the thousands in early computers. They were the on/off switches that allowed computers to function in a language of 1s and 0s.
Life Story: Herman Hollerith (1860-1929)

This text has been provided courtesy of the New-York Historical Society.

C. M. Bell (ca. 1849-1893), Portrait of Herman Hollerith (1860-1929), ca. 1888.

Herman Hollerith was born in Buffalo, but by the time he was 10, he was living in New York City, on 58th Street near the East River. He was the youngest in his household, which also included a brother, two sisters, a brother-in-law, and his mother. His father had died when he was seven. At 12, he enrolled in the prep school division of City College, then called the College of the City of New York, which had been founded specifically for the promising sons of poor families. He finished near the top of his class, and at 15, he entered Columbia University's School of Mines, one of the best science and engineering schools in the country. When he graduated, W. P. Trowbridge, one of his Columbia professors, was working on statistics related to power and machinery at the Census Bureau and offered him a job. Hollerith was 19.

The federal census is done every ten years, as required by the U.S. Constitution. Today, people fill out a form and mail it in, but when Hollerith was a young man, all the information was collected by hired workers known as enumerators. In their assigned districts, they knocked on doors, asked questions, and wrote answers on a form called a schedule. There was one schedule for individuals
and families, and different schedules for businesses and farms. Enumerators were given up to thirty days to finish. Then, following the Bureau's detailed directions, they packed the finished schedules, tied the packages with string, and mailed them to their supervisors.

The Census Bureau's task was to draw statistics from the schedules. How many people lived in New York? How many factories used steam power? The only way to get this information was to hire armies of clerks to read the handwritten schedules one by one and tabulate, or organize, the data. This is where the whole procedure slowed to a crawl. Months went by, years went by, as clerks sat at their desks, making marks in small squares, and then counting and adding the marks.

One of Hollerith's colleagues, Dr. John Shaw Billings, thought a machine could do some of the work, and hoped the inventive young Hollerith might design it. In the early 1880s, they talked about a system created decades earlier by a French weaver named Jacquard, who used cards punched with holes to feed stitching instructions to a mechanical loom. Hollerith began thinking about a punched card system for tabulating the census, and left the Bureau to work full-time on this and other inventions. So he was ready in 1888, when the Census Bureau announced a competition for a tabulating machine that could function on a massive scale, soon. It had taken eight years to process the 1880 census of 50 million people. At that rate, and with the country's population topping 60 million, the 1890 census might not be tabulated before the 1900 schedules arrived.

Hollerith's design beat the other two contestants hands down, and he was given the contract to process and tabulate the 1890 census. For Hollerith's newly designed equipment, it was trial by fire. But his electrical tabulating machine processed the 1890 census in only one year, saving millions of dollars. America was dazzled.

In 1896, Hollerith formed the Tabulating Machine Company, and continued to improve on his invention's design. In 1911, his company merged with three others to form the Computing-Tabulating-Recording Company, which in 1924 became IBM. Punched cards were key to IBM's growth, and remained in use until the 1980s.

In a strange twist, a 1921 fire destroyed most of the 1890 census schedules. Lost were details about individuals, families, businesses, and farms. Aside from a few pages that escaped the blaze, the statistics tabulated by Hollerith's machine are all that remain.
Watson on Jeopardy!

How do you get what you need from a computer? If you want an answer to a question, you go to a search engine like Google, key in your request, and get rewarded with a list of results, sometimes numbering in the millions. Those listed first are most likely to provide your answer, but if not, you have to go hunting, or find a better way to pose your question.

What if you could just ask a question in your own voice, and get the right answer quickly? This has been one of the recent challenges facing computer scientists, and it was behind the design of the IBM computer called Watson, in honor of IBM's first president, Thomas J. Watson, Sr. An IBM team headed by David Ferrucci developed software called DeepQA, to understand and respond to natural language, the kind we speak every day. In 2009, IBM boldly announced that Watson would take on the reigning champions of the television quiz show, Jeopardy! The team spent the next two and a half years preparing for the big night, when Watson would go up against Ken Jennings and Brad Rutter.

Watson would not be connected to the Internet during the show. So millions of pages of documents were uploaded—encyclopedias, dictionaries, novels, plays, religious texts, and more—to give Watson the material it would need to answer questions. But the harder part was programming Watson to respond to the quiz show's format: contestants are given the answers, in tricky wording often full of puns, and have to provide the right question. In practices, Watson sometimes did it correctly, but not often enough. One problem was that it couldn't learn from its own, or the other contestants', mistakes, something the scientists had to correct if Watson was going to stand a chance of winning.

A dress rehearsal was held on January 13, 2011, and the final contest was taped the following day. An avatar for Watson held the center position, between Jennings, on the left, and Rutter, on the right. When the show aired in February, the American audience was enormous.

Many were skeptical. But Watson won, resoundingly. Jennings, who had predicted a human victory, wrote on his screen: "I for one welcome our new computer overlords." Later he said, "I felt obsolete. I felt like a Detroit factory worker in the '80s seeing a robot that could now do his job."

Winning a game show was a very public triumph. But Watson's real work is in the real world. Today, Watson's technology is available to anyone. It is being used to provide doctors with immediate answers to complex questions affecting their patients, and in the travel, banking, finance, and real estate industries.
Code Talkers

Written by Susan Lennox

Photo Credits:

Back cover: Navajo code talker Teddy Draper in 2002

Front cover: Navajo code talkers Henry Blake Jr. and George Kirk operate a portable radio on Bougainville, an island northeast of Australia, during WWII.

Title page: In 2009, Navajo code talker Lloyd Oliver holds a photo of himself from WWII.

Page 3: Navajo code talker Cecil Trosip works a radio in July 1944 on Saipan, an island in the Pacific Ocean between Japan and Hawaii.

Code Talkers
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Civil War Facts

Introduction

The date is February 19, 1945. A platoon of U.S. Marines jumps from a landing craft and struggles through the surf to the beach of Iwo Jima island in the Pacific Ocean, not far from Japan. The marines are greeted by a hail of gunfire from Japanese forces. Unsure of what to do or where to go, the platoon leader radioes his commander for instructions.

All will be lost if the enemy learns of the platoon's plans, but the marines are confident. They have a secret weapon—a team of Navajo (NA-vuh-hoh) radiomen trained to transmit messages in a code no one else can decipher.
Philip Johnston’s Bright Idea

In 1942, World War II was raging across the globe. Many nations, including the United States, had been swept into battle. Communication was vital to keep troops supplied, safe, and ready to do battle.

However, U.S. commanders had a serious problem. Encoded messages sent between units were being intercepted and decoded by the enemy. The Japanese were especially good at breaking U.S. codes. In some cases, this led to many American casualties.

Newspaper stories about the American military’s radio code struggles caught the attention of Philip Johnston. Johnston had lived on the Navajo Indian reservation as a child. While there, he had learned the Navajo language. Johnston was well aware that few people outside of the isolated tribe understood Navajo. He also knew that Navajo was a “hidden language”—it was only spoken and had no corresponding written symbols. These characteristics made it perfect for top-secret communications. When he learned about the problems with message encryption, he was sure he knew a way to solve them.

Johnston contacted military authorities in California about using a code based on Navajo. At first, leaders were skeptical about the plan. However, they finally agreed to a test. If Johnston could show that using Navajo was a fast and secure way to transmit messages, the United States military would try it.
Mysterious Messages

Sending hidden messages dates back to ancient times. Early methods used steganography, a way of physically hiding or disguising a message. Only the sender and the recipient knew how the message was hidden. Sometimes messages were concealed with the use of invisible ink, which seems to disappear once it is applied. Later, heat or chemicals would make the ink visible—and the message clear.

Other steganographic methods were more unusual. One used by ancient Greeks involved shaving a messenger's head, tattooing words there, and then waiting for his hair to grow back and cover the message. The messenger then traveled to the recipient, who would shave his head to read the message.

Most modern coding systems use cryptographic methods. With these methods, the message itself is not hidden, but its meaning is. Even if the message falls into the wrong hands, the reader must know the code in order to understand it.

Cipher Text

How does cryptography work? Here are two different ways to encode the message “Send help now.”

Substitution: A method called the Caesar Cipher involves swapping out each letter in the message for another. Used by the ancient Roman emperor Julius Caesar, it involves swapping letters by simply shifting the alphabet. Here, each letter will shift three letters to the left.

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | A | B | C | D |

"Send help now" becomes "PBKA EBIM KLT."

Transposition: Another method of coding a message involves scrambling the letters. An example is the Rail Fence Cipher. The message is encoded by writing the words alternating on two or more lines, then putting the lines together.

S N E P N W
E D H L O

"Send help now" becomes "SNENPW EDHLO."

At the start of World War II, American military cryptographers constantly changed coding techniques. They even tried using coded American slang, yet their efforts consistently failed. Many Japanese students had been educated in the United States and were familiar with American English. The Japanese code breakers cracked messages almost as quickly as the Americans transmitted them.
Why Navajo?

The idea of using a Native American language was not new. During World War I, the United States had used several Native American languages to successfully transmit messages. Cherokee soldiers helped the 30th Infantry Division send messages from the battlefield during the Second Battle of the Somme. Choctaw men from the army's 36th Infantry Division used code to help Allied forces win important battles in France. Comanche codes helped as well. With such successes using these languages, why did the military switch to Navajo during World War II?

The answer mainly lies with Adolf Hitler, Germany's ruler from 1933 to 1945. Hitler knew that the United States had used Choctaw successfully during the previous conflict. He wanted to make sure they didn't do so again. After World War I, Hitler sent German students to the United States to learn about different Native American languages. The U.S. military was aware of this and knew that Japan had sent students to study these languages as well. For a brief time, U.S. armed forces tried using Native Americans from the Meskwaki tribe. They even attempted to train servicemen of Basque descent to act as code talkers. The populations of these two groups were small, however, resulting in a shortage of eligible native speakers.

Navajo men were numerous and willing to help. Even better, any students—German or Japanese—would have had a hard time learning Navajo. Unlike other Native American languages, Navajo was not an Amerindian language. Navajo (and Apache) belongs to the Na-Dene (nah-de-NAY) language family. At the time, little had been written about that language family. The U.S. Marines had confidence that no one outside the United States would understand the Navajo code.
Communicating in Code

Johnston recruited twenty-nine men for an all-Na'vajo marine platoon. The Na'vajo soldiers worked with the Field Signal School to come up with a system for coding messages that was based on their language. The coding system had two parts. The first part used the Na'vajo translation of English words to stand for letters. For example, the Na'vajo word for “bear” is shush, so the word shush was used for the letter B.

The second part of the system assigned new military meanings to a list of 211 Na'vajo words. Those Na'vajo words were often based on the appearance or function of what each one was describing. For example, owl was used for “observation plane.” The Na'vajo word for shark meant “destroyer.” A “submarine” was called an iron fish.

Na'vajo servicemen were trained from an early age to listen to and learn the stories of their people. They not only had incredible memories, they were also exceptional listeners. Since Na'vajo has a strong oral tradition, the Na'vajo soldiers had no problem memorizing this new vocabulary.

![Two Na'vajo soldiers relay orders over a field radio using the Na'vajo code. In some cases, the soldiers already knew each other from living on the same reservation. These two were cousins.](image)
After a brief training period, Johnston’s plan was ready to be tested. The signal corps conducted time trials to test how quickly and accurately the Navajo soldiers could transmit radio messages. The results were astounding. The code talkers could do in seconds what traditional coders needed half an hour to do!

The military immediately adopted the code and began training more code talkers. Many Navajo men were eager to serve. In total, more than four hundred Navajo code talkers served brilliantly in the Pacific. During one of the biggest battles of the war, the Battle of Iwo Jima, six code talkers sent and received more than eight hundred messages in the heat of combat without a single error. One of those code talkers, Keith Little, described his contribution to the battle: “My weapon was my language, and that language probably saved countless lives.”

**Unsung Heroes**

The Navajo code talkers played an important role in several battles fought in the Pacific during World War II. The Japanese could not make heads or tails of the code. Even after Japan surrendered to the United States on September 2, 1945, the code remained a government secret. The code talkers could not speak about their experiences. They remained silent for years.

The code talkers’ loyalty and patriotism were especially noteworthy given the difficult lives they returned to after the war. Jobs were hard to find for many former soldiers, and Native Americans often faced **discrimination**. Although the United States had extended citizenship to all Native American people in 1924, many tribes were denied the right to vote by individual states. The right to vote wasn’t actually guaranteed to all Native Americans until forty years later.

**A Vote = A Voice**

Until 1965, individual states were able to use various methods to keep Native Americans and other minorities from voting. The Voting Rights Act outlawed all of that, making it possible for minorities to actually exercise their right to vote.
Finally, in 1968, the secrecy surrounding the code talker program ended. The world then learned about the amazing contributions of these men. In December of 2000, President Clinton signed a law awarding the Congressional Gold Medal to the twenty-nine original Navajo code talkers. In a 2001 ceremony at the U.S. Capitol, President Bush presented medals to four of the five surviving members of that group.

The unusual Navajo language and the honorable actions of the code talkers contributed to the success of the code and, in turn, to victory during the war. To this day, it is the only spoken military code that has never been broken.

Glossary

**casualties** *(n.)* people wounded or killed during a war, accident, or disaster (p. 5)

**code talkers** *(n.)* Native American soldiers who used their native language as a code during World Wars I and II (p. 10)

**cryptographic** *(adj.)* of or relating to the use of a cipher or code for the reading or writing of secret messages (p. 7)

**decipher** *(v.)* to make out the meaning of something that is difficult to understand; to decode (p. 4)

**discrimination** *(n.)* the unfair treatment of a person or group based on gender, race, age, religion, or other differences (p. 14)

**encryption** *(n.)* the act of coding a message in order to hide its meaning (p. 5)

**intercepted** *(v.)* stopped or took a message that was traveling from one place to another (p. 5)

**Navajo** *(n.)* a member of a Native American people in the Southwest; the language of these people (p. 4)

**recipient** *(n.)* one who receives something (p. 7)

**reservation** *(n.)* land set aside by the U.S. government for Native Americans (p. 5)

**translation** *(n.)* words from one language that have been changed to another language (p. 11)

**transmit** *(v.)* to pass something from one person to another (p. 4)
CODE CRACKERS: CAESAR CIPHER

BACKGROUND

The Caesar cipher is named after Julius Caesar, who used it to transmit military secrets in Ancient Rome. It is a simple substitution cipher, in which each letter of the original message (called the plaintext) is replaced by a letter further along in the alphabet. However, it is a simple cipher and not very difficult to break. Each cipher uses a shift key value (Caesar originally used a value of 3).

HOW IT WORKS

If we use a right shift of 3, when we are encrypting a message, A would become D, B would become E, and so on. For letters at the end of the alphabet, it would wrap around; so X would become A, Y would become B, etc. It is easy to see these shifts by sliding two pieces of paper with alphabets written on them, or by using a cipher wheel.

To encrypt a message, we will shift each letter 3 places to the right.

Plaintext: THIS IS A SECRET MESSAGE
Ciphertext: WKLV LV D VHFUHW PHVVDJH

To decrypt the message, we would then reverse the process and shift each letter 3 places to the left.

Ciphertext: WKLV LV D VHFUHW PHVVDJH
Original text: THIS IS A SECRET MESSAGE

PRACTICE

First, practice deciphering the following message. It has a shift of 3 (so on your cipher wheel you would line up your outer A with your inner D).

VHFUHW FRGHV DUH FRRO

Now, try to decipher this message. You will have to figure out what the shift is yourself. Try experimenting with different shifts on the cipher wheel.

JKUVQTA KU HWNN QH UGETGVU

If you have successfully figured out the previous two messages, move on the Master Code Cracker section to learn some facts about Ancient Rome!
MASTER CODE CRACKER

Now that you've mastered the Caesar cipher, see if you can crack the following codes!

1. Olih hashfdqff 1q Dqfilhqw Urph zdv iurp wzhqwb wr wkluwb bhdv.

2. Nshkphavzy dylv jvtihahuaz dov mvbnoa hnhpuza lhjo vaoly, jvukltuljk jyptpuhsz huk dpsk hupthsz.

3. Xli Gspmiyq gsyph lsywi imklxc xlsywerh wtigxexsvw.


5. Oudoge Ymjuyge ime mz mzouqzf Daymz otmduaf dmouzs efmpugy.

ENCODE YOUR OWN MESSAGES

Use your cipher wheel to create secret messages for your friends. Don't give them the shift key and see if they can figure it out!
Create your own cipher wheel!

Cut out the circles and attach them together with a brass fastener.
**Code Cracker Key**

**PRACTICE**

SECRET CODES ARE COOL

HISTORY IS FULL OF SECRETS (Shift Key = 2)

**MASTER CODE CRACKER**

1. **Shift Key = 3**
   Life expectancy in Ancient Rome was from 20 to 30 years.

2. **Shift Key = 7**
   Gladiators were combatants who fought against each other, condemned criminals and wild animals.

3. **Shift Key = 4**
   The Coliseum could house eighty thousand spectators.

4. **Shift Key = 9**
   The Ancient Romans invented roads.

5. **Shift Key = 12**
   Circus Maximus was an ancient Roman chariot racing stadium.
Below is a secret message. Each mathematical symbol and number combination (e.g. x3) can translate to a letter. You will use FREQUENCY ANALYSIS to crack the code. Count the number of times each symbol/number appears in the message using the grid below. Then follow the instructions on the following pages.

Here is an enciphered message found in a suspected spy's apartment. We believe it can tell us about a secret meeting somewhere in Washington, DC. Use the following pages to help you crack the code!

\[
\begin{array}{cccccccc}
x3 & -5 & -5 & +1 & x3 & -5 & -1 & +1 & +1 \div 3 & -5 \\
\end{array}
\]

\[
\begin{array}{cccccccc}
x2 & \div 2 & x4 & -3 & x5 & x2 & x4 \\
\end{array}
\]

\[
\begin{array}{cccccccc}
x3 & -5 & x3 & x5 & +3 \div 2 & -1 & x2 \\
\end{array}
\]

\[
\begin{array}{cccccccc}
x3 & -5 & +1 & -1 \div 3 & x2 & \div 2 & x4 & -3 & x5 & +3 & -2 \\
\checkmark & \checkmark & \checkmark & \checkmark & \checkmark \\
\end{array}
\]

\[
\begin{array}{cccccccc}
4 \\
\end{array}
\]

DESTROY THIS ⚠️ AFTER READING

VISIT SPYMUSEUM.ORG
We are assuming this message will decode into English—that means that each math symbol with a number will translate to a letter of the alphabet and each space between the symbols indicates a new word. You will use Frequency Analysis to crack this message. **Here's How:**

**Step 1:**
Use the grid beneath the message to count how many times each symbol/number combination appears in the message (it's frequency).

**Step 2:**
Look at your totals, which combination appears most? Consult page three to see which letter(s) in the English language appear most frequently.

**Step 3:**
Use a pencil (you may need to erase) and try placing the most frequently used letter (E) under the most frequently appearing symbol.

**Step 4:**
Now look at the patterns in the English language on page 3 and begin trying out letters until a word forms.

**Step 5:**
Once you think you have a word, Go through the message and replace those same symbols with those same letters and try to solve this message.

**Step 6:**
Don't get frustrated! Just keep trying different combinations.
**E** is the most common letter used in words. Other common letters:

T, A, O, N, I, R, S, H

Least commonly used letters:

J, K, Q, X, Z

Common double letter combinations:

EE, OO, LL, TT, SS

Some common two-letter combinations:

EN, RE, ER, TH

The only one-letter words:

A & I

More about the letter **A**:

*Often found at the beginning of the words and second from the last letter*

More about the letter **I**:

*Often found third from the last letter of a word (think...ing)*

Commonly used words:

The, That, And, Will, A, I, Is, It, In
Grace Murray Hopper (December 9, 1906 – January 1, 1992) is a legendary American computer scientist, a US Navy rear admiral, professor of mathematics, and computer programming inventor.

Key Facts & Information

EARLY LIFE

- Full name: Grace Brewster Murray Hopper.
- Grace was born in New York. Her parents were Scottish and Dutch. Her great-grandfather was a US Navy admiral during the Civil War. She was a curious and smart kid. Grace Hopper went to preparatory school in New Jersey.
- Hopper’s curiosity was so strong, that once when she was a child, she dismantled eight alarm clocks in order to understand how alarm clocks worked.
- When she was sixteen, she not permitted to attend the Vassar College because she had problems with Latin, but the next year she applied again and everything went well.
- Grace graduated with a bachelor’s degree in mathematics and physics, and also got a master’s degree at Yale.
- Later, she also got a Ph.D. in mathematics at Yale and wrote a dissertation “New Types of Irreducibility Criteria”. After that she started to work at Vassar College and ten years after that, she became a professor of mathematics.

DISCOVERIES AND INVENTIONS

- When World War II started, she decided to go to the US Navy, but was rejected because of her age (she was already 34), because of her small weight and height, and she was told that her work as a professor at Vassar was much more valuable for the efforts of war.
- In 1943, she took the oath in the US Navy reserve, as did many of the women who volunteered in WAVES (Women in Voluntary Emergency Services).
- She was accepted as an exception. She entered the service in December and studied at the Reserve Cadet School at Smith College. Hopper finished her studies with the best results in the class and was promoted to the artillery computing project bureau at Harvard University as a junior lieutenant.
- She has been programming on the Mark I computer under the guidance of Howard Aiken. Aiken and Hopper co-authored three articles on the Mark I computer, also known as a counting device with an automatic sequence of operations.
- In 1949, Hopper became an employee of Eckert-Mauchly Computer Corporation and, as a senior mathematician, joined the UNIVAC I computer development team. In the early 1950s, their team released the first-ever compiler. It was known as “A Compiler”, and its first version was A-0. This is how Grace reacted: “Nobody believed that,” she said. “I had a running compiler and nobody would touch it. They told me computers could only do arithmetic”.
- Grace always dreamt of inventing a programming language that would be close to English. And in 1959, she worked with other computer experts on creating a new computer programming language COBOL (an acronym for Common Business-Oriented
Language). This language was a combination of Hopper’s FLOW-MATIC language with some ideas from the IBM equivalent, COMTRAN.

- So a dream to create close to English programming language came true and COBOL is still in active use nowadays.
- In the 70’s, Hopper convinced the government to replace centralized computer systems that were too big with a network of small computers. She also created a system of standards for testing computer systems and components, especially for FORTRAN and COBOL languages.
- Grace Hopper retired twice. First in 1966 and second time in 1971, but both times she was recalled to active duty because of her knowledge and skills.
- In 1985, she became a commodore by special Presidential appointment. Later commodore was renamed to rear admiral, and Grace became one of a few female admirals of those times.
- When Grace finally retired at the age of 79, she was the oldest active-duty commissioned officer in the United States Navy.
- Her first nickname was “Amazing Grace”.
- After leaving the US Navy, she started her lecturing career: she visited students and told them about early computer programming era.
- Grace also supported students a lot, she once said: “The most important thing I’ve accomplished, other than building the compiler,” she said, “is training young people.” They come to me, you know, and say, “Do you think we can do this?” I say, ‘Try it.’ And I back ‘em up. They need that. I keep track of them as they get older and I stir ’em up at intervals so they don’t forget to take chances.”
- In her later years, she got known for her specific lively communication style, and for that she got her second nickname “Grandma COBOL”.
- Grace also is known for creating a term “debugging” in the meaning on fixing the system. The story of how this word appeared is short: once Grace with her team discovered a moth that was stuck in a relay; the moth impeded the operation of the relay. And Hopper said that they needed to do some debugging.
- Hopper created a metonym nanoseconds. She was often asked by Navy admirals why the satellite communication made you wait so long. And Hopper found a good and simple explanation. She handed out pieces of wire that were one foot long (11.8 inches) and said that this is the exact distance that light travels in one nanosecond.
- She named these pieces of wire nanosecond, and the Navy admirals understood.

DEATH AND LEGACY

- Grace Brewster Murray Hopper died on New Year’s Day in her sleep. She was 85 years old.
- She was interred with full military honors in the Arlington National Cemetery.
- During her life, Grace Hopper was awarded 40 honorary degrees from universities all over the world.
- There is an upcoming documentary film called Born with Curiosity: The Grace Hopper Story.
Frida Kahlo was a Mexican painter, known for mixing traditional Mexican folk art with surrealism. Surrealism is a form of painting that is inspired by dreams and uses images that are symbolic of other things.

When Frida was young, she was enrolled in a prestigious school where she was studying medicine. While there, she was in a terrible trolley accident that broke nearly all of her bones. She healed and was able to walk again, but the pain remained with her for the rest of her life. After the accident she decided to devote herself to painting, which was what she loved to do.

At a young age she married the already famous painter Diego Rivera. His work was usually large painted murals that depicted the struggle of the working class in Mexico.

Frida’s paintings, however, were much more personal. She painted many self-portraits, and also many works about her heritage. After becoming famous, she spent most of her time in the U.S. She valued the traditional Mexican way of life, but was living in a heavily industrialized country. In one of her self portraits she is painted in the middle of the canvas; in one half the scenery behind her are metal tubes and smoke stacks, on the other there are scenes of traditional Mexican life and ancient relics.

Many of Frida’s paintings have symbols in them that are used repeatedly. One of the symbols she often used was a monkey that is native to Mexico. Christian symbols, such as the crucifix and the crown of thorns, are used in her work as well. The use of symbols, and the theme of identity in her work, is what caused many people to consider it surrealism. However, it is sometimes called magic realism, which is a style that shows very realistic things in unlikely situations. Many South American writers around Frida’s time used this name to describe the work they were doing.
FRIDA KAHLO EXERCISE

Most of Frida's work was about her identity and where she was from. She created many paintings about it, but also did a lot of writing. On the back of this page, write a paragraph about where you are from. Then sketch a picture to go along with it.
Mysterious Mayan Writing

The Maya were American Indian people who lived in Mesoamerica, an area that today is made up of parts of Mexico and Central America. The Maya were one of the first great civilizations of the Americas that flourished between 200 and 900 CE. Since the mid-1800s, when two Americans explored and wrote a book about the ruins of an ancient Mayan city called Copán, archaeologists have studied these remarkable people.

Mayan Hieroglyphs

Archaeologists found hieroglyphs (/hie*roe*glifs/) carved into Maya buildings and monuments. The Temple of the Hieroglyphic Stairway stands in Copán. A climb up this staircase is a journey back in time. Each of the sixty-three steps has a story to tell. Carved symbols called glyphs name all of the rulers of Copán. The glyphs also explain their military victories. The American explorers who visited this site in 1839 marveled over these carvings. They could not, however, figure out what the symbols meant. For a long time, neither could any other experts.

Hieroglyphs are like a code. You must crack the code to read the messages. Mayan hieroglyphs are complicated and include more than eight hundred symbols. It wasn’t until the 1960s that archaeologists began to crack the code with early computers. Since then, we have learned a great deal about the ancient Maya.

Breath on a Mirror

From Mayan hieroglyphs, we have learned that daily life for the Maya revolved around family, farming, and service to the gods. No person or group took any important action without
consulting the gods. Priests decided which days were best for planting a field, starting a war, or building a hut. The Maya believed the gods were much wiser than humans.

According to Maya legend, the first people could see everything. The creator gods decided that this gave people too much power. So the gods decided to limit human sight and power. The Maya sacred book, the Popol Vuh, explains that the gods purposely clouded human understanding. As a result, a human's view of the world is unclear. The Popol Vuh explains that human understanding is "like breath on a mirror."

A Mayan Game

Breaking the hieroglyph code also helped archaeologists understand how the Maya spent some of their time. A specific kind of ball court can be found in many Maya cities. Archaeologists were puzzled about these courts, which varied in size. Some were the size of volleyball courts. Others were larger than football fields. Archaeologists now think the Maya played a game called pok-ta-pok in these courts. They believe the goal of pok-ta-pok was to drive a solid rubber ball to a specific place on the opponents' side of the court.
Learn Morse Code

You can write Morse code, or send it via sounds or lights. Dots represent a short sound or light, and dashes a long sound or light.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Created by Kate Fardig picklespots.com © 2018 for personal non-commercial use only.
How to solve PigPen Ciphers

PigPen Ciphers are similar to Morse code where you have to substitute symbols for letters of the alphabet.

The letter N would be symbolized as a square with a dot inside. Where as the letter T would look like the greater than symbol.

PigPen Cipher Key
Learn The Pigpen Cipher

This is a very old code that is easy to write. Can you work it out?

A | B | C | J | K | L
---|---|---|---|---|---
D | E | F | M | N | O
G | H | I | P | Q | R

S X T U V W Y Z
Write Your Own Secret Code!

Create a symbol for each letter and number and write or draw them in the boxes below. When you are done write a message in your very own top secret code!

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<td>9</td>
</tr>
</tbody>
</table>
As long as there have been secrets there have been codes—they are a spy’s best friend or worst enemy. Do you have what it takes to become a code master? Try your hand at cracking this top secret message:

There are 3 code/cipher systems used in this message. The tools you will need begin at the bottom of this sheet. The methods are:

- Cipher Wheel: each letter of the alphabet is substituted with another letter.
- Pig-Pen Cipher: each letter of the alphabet is substituted with a graphic representation or a symbol.
- Navajo Code: The Navajo Code-Talkers used the Navajo language during WWII to translate military terms into this almost unknown Native American language.

*Before starting, cut this message out and turn this sheet over so you can use your tools while looking at the message.*

**YOUR TOOLS:**

**Navajo Code-Talker Key:**
The translation is not word for word so this code is a form of double-encryption.

- **A-YE-SHI** (Eggs) = Fighter Plane
- **DAH-HE-TI-HI** (Hummingbird) = Observation Plane
- **DEBEH-LI-ZINE** (Black Street) = Bombs
- **NE-AS-JAH** (Owl) = Submarine
- **BESH-LO** (Iron Fish) = Squad

To find out about KidSpy® and other programs at the International Spy Museum visit www.spymuseum.org ©2008 The House on F Street, LLC All Rights Reserved.
How to make and use your cipher wheel:

1. Carefully cut out both disks.

2. Place the smaller disk on top of the larger disk.

3. Use a paper fastener (brad) to attach the inner disk to the outer disk. Push it through the middle of both disks and then bend the out the tabs underneath the disks.

4. You are now ready to decipher the message. Just use the key A=X and crack the code.

**PIG-PEN CIPHER KEY**

Simple shapes and dots create symbols that correspond to each letter of the alphabet. The letter placed in each cell takes that cell’s shape so for example:

> ☐ ☐ ☐ ☐ ☐ = TOP SECRET

Answer for Secret Note:

NOW SQUAD NEEDED AT NOON SEND NIGHT PLANE ARRIVING AT MIDNIGHT SUBMARINE EYES ONLY
# Matching Pictographs to Charts

Name:

Determine which pictograph best represents the information in the chart.

<table>
<thead>
<tr>
<th>Store</th>
<th>Movies Sold</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVD World</td>
<td>8</td>
</tr>
<tr>
<td>Movies Etc</td>
<td>80</td>
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<tr>
<td>Video Hut</td>
<td>72</td>
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<tr>
<td>Dvd Shop</td>
<td>48</td>
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<tr>
<td>Cinema Hut</td>
<td>64</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Store</th>
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<tbody>
<tr>
<td>DVD World</td>
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<td>Movies Etc</td>
<td>32</td>
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<tr>
<td>Video Hut</td>
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<tr>
<td>Dvd Shop</td>
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<tr>
<td>Cinema Hut</td>
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</table>

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<th>Store</th>
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<td>Video Hut</td>
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<tr>
<td>Cinema Hut</td>
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<table>
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<th>Store</th>
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<td>Movies Etc</td>
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<th>Store</th>
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<td>Cinema Hut</td>
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<th>Store</th>
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<tr>
<td>Cinema Hut</td>
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</tbody>
</table>

A) ![Pictograph](image1.png)

Each ○ = 8 movie sold

B) ![Pictograph](image2.png)

Each ○ = 8 movie sold

C) ![Pictograph](image3.png)

Each ○ = 8 movie sold

D) ![Pictograph](image4.png)

Each ○ = 8 movie sold

E) ![Pictograph](image5.png)

Each ○ = 8 movie sold

F) ![Pictograph](image6.png)

Each ○ = 8 movie sold
Determine which pictograph best represents the information in the chart.

<table>
<thead>
<tr>
<th>Store</th>
<th>Movies Sold</th>
<th>Store</th>
<th>Movies Sold</th>
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4) Store       | Movies Sold |
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<td>DVD World</td>
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<td>Movies Etc</td>
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<td>Video Hut</td>
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<td>Dvd Shop</td>
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<tr>
<td>Cinema Hut</td>
<td>80</td>
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5) Store       | Movies Sold |
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<td>DVD World</td>
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<td>Cinema Hut</td>
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6) Store       | Movies Sold |
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<td>DVD World</td>
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A) Store       | Movies Sold |
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<td>DVD World</td>
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<tr>
<td>Movies Etc</td>
<td>★☆★☆★☆☆☆☆☆☆</td>
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<tr>
<td>Video Hut</td>
<td>★☆★☆★☆☆☆☆☆☆</td>
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<tr>
<td>Dvd Shop</td>
<td>★☆★☆★☆☆☆☆☆☆</td>
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<tr>
<td>Cinema Hut</td>
<td>★☆★☆★☆☆☆☆☆☆</td>
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Each ⋄ = 8 movie sold

B) Store       | Movies Sold |
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<tr>
<td>DVD World</td>
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<td>Dvd Shop</td>
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<td>Cinema Hut</td>
<td>★☆★☆☆☆☆☆☆☆☆☆</td>
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Each ⋄ = 8 movie sold

C) Store       | Movies Sold |
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<td>DVD World</td>
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<td>Movies Etc</td>
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<td>Cinema Hut</td>
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Each ⋄ = 8 movie sold

D) Store       | Movies Sold |
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<td>DVD World</td>
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<td>Movies Etc</td>
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<td>Video Hut</td>
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<td>Cinema Hut</td>
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Each ⋄ = 8 movie sold

E) Store       | Movies Sold |
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<td>Movies Etc</td>
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Each ⋄ = 8 movie sold

F) Store       | Movies Sold |
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<td>Movies Etc</td>
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<td>★☆☆★☆☆☆☆☆☆☆☆</td>
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<td>Dvd Shop</td>
<td>★☆☆★☆☆☆☆☆☆☆☆</td>
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<tr>
<td>Cinema Hut</td>
<td>★☆☆★☆☆☆☆☆☆☆☆</td>
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Each ⋄ = 8 movie sold
Bioglyphs

Use these symbols to create your bioglyph diagram.

**Face Shape:**
- [ ] Male
- [ ] Female

**Hair Color:**
- [ ] Blonde
- [ ] Black
- [ ] Brunette
- [ ] Red

The # of strands indicates the month of birthday.

Long strands indicate long hair, while short strands represent short hair.

**Eye Color:**
- [ ] Green
- [ ] Blue
- [ ] Brown
- [ ] Hazel

An oval eye shape indicates glasses or contacts. A circular shape indicates perfect vision.

**Eyebrows:**
- (Favorite color)
  - [ ] Red
  - [ ] Blue
  - [ ] Green
  - [ ] Purple
  - [ ] Other

**Nose:**
- △ Rides bus to school
- ▼ Rides in car
- [ ] Rides bicycle
- [ ] Walks

**Necklace:**
- [ ] On a sports team
- [ ] Member of band or chorus
- [ ] Member of a club/group
- [ ] No charms = None of the above

**Ears:**
- ( ) Sister(s)
- ( ) Brother(s)

Use dots (*) inside the ear indicates number of siblings. Dots in upper ear indicates older sibling(s). Dots in the lower ear refer to younger sibling(s).

**Mouth:**
- [ ] Loves science
- [ ] Thinks science is ok
- [ ] Thinks science is scary
- [ ] Does not like science

**Cheeks:**
- [ ] Likes vanilla ice cream
- [ ] Likes chocolate ice cream
- [ ] Other

**Freckles:**
The # of freckles indicates the day of birthdate.

**Eyelashes:**
The # of eyelashes indicates the # of pets.
Bioglyph Challenge

Use your investigative powers to match each classmate with their bioglyph. You are allowed to ask questions that require a yes or no answer. ("Is this your bioglyph?" is not an acceptable question!)

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<td>30.</td>
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</table>
Bio = Life + Glyph = Symbols

What do we know about this person from their bioglyph?

Face Shape:
- Male
- Female

Hair Color:
- Black
- Brunette
- Red

The # of strands indicates the month of birthday.
Long strands indicate long hair, while short strands represent short hair.

Eye Color:
- Brown
- Blue
- Green
- Hazel

An oval eye shape indicates glasses or contact lenses. A straight shape indicates perfect vision.

Eyebrows:
- Favourite color!
- Red
- Blue
- Green
- Purple
- Other

Name:
- Rides bus to school
- Rides in car
- Rides bicycle
- Walks

Necklace:
- On a sports team
- Member of band or chorus
- Member of a club/group
- No choice - None of the above

Ears:
- Sister(s)
- Brother(s)

Use dots (* inside the car indicates number of siblings. Dots in upper or indicate older sibling). Dots on the bottom car refer to younger siblings.

Mouth:
- Loves science
- Thinks science is OK
- Thinks science is scary
- Does not like science

Cheeks:
- Likes vanilla ice cream
- Likes chocolate ice cream
- Other

Forehead:
The # of folds indicates the day of the birthday.

Eyelashes:
The # of eyelashes indicates the # of pets.
1st – Choose the right face shape.

2nd – Add the hair to show your hair color and length as well as the month you were born.

- # of strands = Month - Jan = 1, Feb = 2, etc.
- Style = Color of your hair
- Length = Short (Less than 1”)
  Medium (Between 2 - 4”)
  Long (More than 4”)

3rd – Add the eyes to show the color of your eyes and whether or not you wear glasses or contacts.

- Oval = Glasses or contacts
- Circle = Perfect vision
- Position of the eyeball = Color of your eyes

4th – Add eyebrows to show your favorite color.

5th – Add a nose to show how you get to school MOST days.

6th – Add charms to show the sports you play or the clubs and groups you are in this year.

Add one shape for each one you are in or plan to be in this year. For example, someone who played football, is playing basketball, and is in Science Club, would have two circles and one star.
7th – Add ears to show if you have brothers and sisters as well as if they are older or younger than you.

Sisters = ear on the left side and brothers = ear on the right side

Add dots to show the number of older or younger sisters or brothers.

8th – Add a mouth to show if you like science.

9th – Add cheeks to show your favorite kind of ice cream.

10th – Add freckles to show the day of your birthday.

For example, someone born on January 26th would have a total of 26 freckles. Put them all on one cheek or split them between the two cheeks.

11th – Add eyelashes to show the number of different kinds of pets you have.

For example, someone who has three dogs, two cats, a bird, and some fish, would have four eyelashes total since they have four different kinds of pets. Put all your eyelashes on one eye or split them between the two eyes.

12th – Write your name lightly on the back of the page so that it does not show through. Turn it in to your teacher.
Bioglyph Challenge
Can you identify your classmates?

RULES:
• You can only ask questions that require a YES or NO answer.
• You cannot ask, “Is this your bioglyph?” or similar questions.
• Use your quiet voices and keep your papers covered to prevent people from getting easy answers.
• Write the person’s name on the line on your worksheet that has the same number that is on their bioglyph page.
• Questions?
Use this code to help you answer each item:


Break the Code: Earth Science

1. 5-10-5-3-20-1 is the material thrown out by a volcano.


3. 7-5-15-20-8-5-18-13-1-12 energy is energy from the earth’s internal heat.

4. Once magma reaches the earth’s surface, it is called 12-1-22-1.

5. 13-1-7-13-1 is molten rock beneath the earth’s surface.

6. 19-5-1 12-5-22-5-12 is the top of the ocean.

7. 19-5-4-9-13-5-14-20 is rock debris.


Fancy Folding Codes

If you know how to make a paper fan then you can crack these secret messages

Instructions

1. Click on one of the designs below and print out
2. Start by cutting along the dotted line
3. The design now needs to be folded like a fan. Your first fold is to the first set of lines either side of the design
4. Flip over and fold exactly back on itself
5. Carry on in this fashion as neatly as you can until you reach the end of the pattern
6. Now gently stretch out the fan and hold up to eye level.
7. If you have folded it correctly you should see a secret message!

Fold like a fan
FORMULA #1

» 1 Tablet of Laxative
» 1 Tablespoon Rubbing Alcohol
» Cotton balls
» Household Ammonia

Mash the laxative tablet into the tablespoon of alcohol. Be sure the tablet is entirely dissolved. Write a message on the paper with paintbrush dipped into the solution. As the solution dries, the writing will disappear. To develop the message: dampen the cotton ball with liquid ammonia and dab it on the page. The writing will reappear.

FORMULA #2

» Lemon Juice
» Heat Source

Write your message in lemon juice and wait for it to dry. Use a hair dryer, iron or light bulb (carefully) to expose the message.

FORMULA #3

» Vinegar
» Heat Source

Write your message in vinegar and wait for it to dry (or use hair dryer). Use a hair dryer, iron or light bulb (carefully) to expose the message.

FORMULA #4

» Whole Milk
» Heat Source

Write your message in milk and wait for it to dry. Use a hair dryer, iron or light bulb (carefully) to expose the message.

FORMULA #5

» Vinegar or Lemon Juice
» Red Cabbage Water
(chop one large red cabbage into small pieces
Note: blackberries, red onions, or even hibiscus flowers can be used as well - simmer the cabbage pieces until the water turns a deep shade of purple.
Allow the water to cool. Refrigerate when not in use).

Write your message in lemon juice or vinegar and wait for it to dry (or use hair dryer). Using a spray bottle, mist red cabbage water over it to expose the message.

FORMULA #6

» 3 Tablespoons Baking Soda
» 3 Tablespoons Water
» Grape Juice

Mix about 3 tablespoons of baking soda and 3 tablespoons water. Write with this mixture on paper and let it dry. Paint or rub the grape juice across the paper to expose the message.

FORMULA #7

» 1 Teaspoon Corn Starch
» 1/4th Cup Water
» Lodine
» Water

Mix the corn starch with the water. Heat it a little, about 30 seconds in a microwave. Stir it and let it cool. Write your message on paper and let it dry. To expose the message wipe the surface of the paper with a sponge this has been wetted in iodine and water.

FORMULA #8

» Whole milk
» Sandpaper
» Pencil

Write a secret message with whole milk. Let it dry. Scrape the pencil point with the sandpaper, letting the pencil dust fall on the message area.

VISIT SPYMUSEUM.ORG
SECRET MESSAGE EGG CHALLENGE

WHAT YOU NEED

» Small bowl
» Measuring cup
» Alum (can find in the spice aisle at your local supermarket)
» White vinegar
» Q-tips
» Hard-boiled egg

WHAT TO DO

In the bowl, dissolve one part alum in one part vinegar. Mix well. Use the Q-tips cotton swab to write or draw something on the eggshell using the alum and vinegar solution as ink. Let dry. Remove the eggshell from the egg.

WHAT HAPPENS

The alum-and-vinegar solution dries invisible, but when the eggshell is removed the writing is visible on the egg’s surface (the egg is still edible).

WHY IT HAPPENS

The vinegar (acetic acid) dissolved the calcium carbonate in the eggshell, allowing the alum to permeate the shell and discolor the egg white.

*Ok, we have to admit, we've never gotten this to work. If you're successful, e-mail us a photo at educators@spymuseum.org and we'll send you a prize!