



SILICON CITY™

Computer History Made in New York

**Classroom Materials for the
Exhibition**

NEW-YORK
HISTORICAL
SOCIETY
MUSEUM & LIBRARY
MAKING HISTORY MATTER

Acknowledgments

★ **AT&T** is proud to support the *Silicon City* classroom curriculum and highlight the stories of pioneering women throughout the history of technology—noted by this symbol ★—as part of the company's steadfast commitment to supporting STEM education.



The New-York Historical Society acknowledges with gratitude the generous cooperation of IBM in the development of *Silicon City: Computer History Made in New York*.

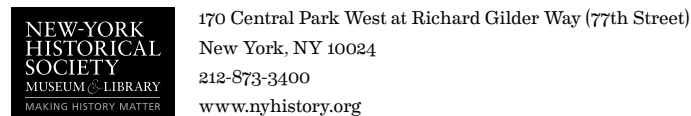


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THE NEW-YORK HISTORICAL SOCIETY

Since its founding in 1804, the New-York Historical Society has been a mainstay of cultural life in New York City and a center of historical scholarship and education. For generations, students and teachers have been able to benefit directly from our mission to collect, preserve, and interpret materials relevant to the history of our city, state, and nation. The New-York Historical Society consistently creates opportunities to experience the nation's history through the prism of New York. Our uniquely integrated collection of documents and objects is particularly well suited for educational purposes, not only for scholars but also for schoolchildren, teachers, and the larger public.



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Table of Contents

Acknowledgments	2	Resources	39	Appendix	59
Letter from the President, Dr. Louise Mirror	4	Resource 1: Hollerith's Electrical Tabulating Machine	40	Writing Numbers in Binary: An Infographic	60
About the Exhibition	5	Resource 2: Punched Cards	41	A Computer in Your Pocket: An Infographic	61
Classroom Notes	7	Resource 3: The Three Laws of Robotics	42	Predicting 2015— High School Essays from 1965	62
About the Curriculum	8	Resource 4: Women Programmers of ENIAC	43	Silicon City Now	64
How to Navigate	8	Resource 5: The Transistor	44	Glossary	65
Materials in the Curriculum	9	Resource 6: Walter Cronkite and UNIVAC	45	Books and Websites	66
Suggested Activities	10	Resource 7: The First Transatlantic Telephone Cable	46	Source Notes	67
Pre- and Post-Visit Activities	11	Resource 8: The IBM Pavilion at the World's Fair	47	Standards	69
Social Studies Activities	13	Resource 9: Design and Branding	48	Worksheets, Infographics, and Printable Resources	77
Cross-Curricular Activities	19	Resource 10: Watson on <i>Jeopardy!</i>	49		
Technology Activities	23	Resource 11: <i>A Brief History of Computer Graphics: Made in New York</i>	50		
Visual Arts Activities	29				
Silicon City: A Timeline	35	Life Stories	51		
		Samuel F. B. Morse (1791–1872)	52		
		Thomas A. Edison (1847–1931)	53		
		Herman Hollerith (1860–1929)	54		
		Grace Hopper (1906–1992)	55		
		Thomas J. Watson, Sr. (1874–1956) and Thomas J. Watson, Jr. (1914–1993)	57		

Symbol Key

	Silicon City: A Timeline
	Resources
	Life Stories
	Silicon City Now
	Stories of pioneering women in technology

Letter from the President, Dr. Louise Mirrer

Dear Educator:

The New-York Historical Society is proud to present this collection of educational materials and resources to accompany *Silicon City: Computer History Made in New York*. The exhibition highlights the little-known but seminal role New York played in the digital revolution. Beginning with early technological innovations that laid the groundwork for modern computing, such as Samuel Morse's telegraph, the exhibition spans the twentieth century and beyond, including the evolution of computing during and after World War II, the 1964 New York World's Fair, and the city's resurgence as a tech hub today. *Silicon City* is on view November 13, 2015 through April 17, 2016.

Our educational materials draw on the exhibition's major themes and topics, underscoring this story's relevance to social studies, computer science, and visual arts classrooms. The curriculum, intended for use by teachers and students, includes background content, classroom activities, and primary resources, and meets the Common Core State Standards as well as the New York State Social Studies Framework. In addition, it supports the New York City Department of Education's *Blueprint for Teaching and Learning in Visual Arts*. Elements within these classroom materials, including photographs, ephemera, text, and a film, illustrate the decades-long evolution of technology and the tech industry. Life stories provide a close, personal look into the lives of both prominent and lesser-known people involved in the history of computing, highlighting the impact of individuals' ideas and actions, and revealing the central role women played in early computer science. The classroom poster depicts a diverse cross section of people working

in the New York tech sector today to inspire students to see their own potential in the industry's workforce.

The Education Division of the New-York Historical Society is committed to providing stimulating materials and programming to enhance the teaching and learning of New York and American history in the classroom. This collection of materials and resources has been designed both to complement and extend school visits to the exhibition and to help teachers and students from across the country discover the New York roots of today's wired world.

To learn more about school programs designed for *Silicon City: Computer History Made in New York* and all education programs at the New-York Historical Society, please do not hesitate to contact us at (212) 485-9293 or visit the Education Division online at www.nyhistory.org/education.

Sincerely,



Louise Mirrer, Ph.D.
President & CEO
New-York Historical Society



About the Exhibition

Silicon City: Computer History Made in New York **New-York Historical Society** **November 13, 2015 – April 17, 2016**

S*ilicon City: Computer History Made in New York* celebrates New York's central role in the digital revolution, highlighting the pioneering work and technological innovations that have transformed daily life. It presents the city as a technological hub, where the intersection of commerce and innovation gave birth to the first computers and tech companies.

Organized by New-York Historical's Chief Curator Stephen Edidin, with assistance from Research Associate Cristian Panaite, the exhibition presents a dynamic timeline of computer-related milestones in the New York region from the mid-1800s to the 1980s, and concludes with a multimedia showcase of the companies and individuals who have reinvigorated today's city into a digital capital. It features over 180 artifacts, including early computers and telecommunications hardware, archival materials, photographs, digital artworks, and interactive experiences that will immerse visitors in the decades-long evolution of technology.

Exhibition Highlights

In *Welcome to the Fair*, the exhibition greets visitors with an experiential retelling of the moment that introduced the general public to computing: the IBM Pavilion at the 1964 New York World's Fair.

Every fifteen minutes for nearly a year, 500 curious visitors entered the Eero Saarinen-designed theater known as "the Egg" to view a multimedia experience called "THINK" by Charles and Ray Eames. The physical

and multimedia recreation of "the Egg" experience is complemented by vintage posters and archival materials from the fair, transporting visitors back in time to the dawn of the Information Age.

Upon exiting "the Egg," visitors are immersed in the first thematic section of the exhibition's technology timeline: *The Evolution of a Revolution*. New York-based innovations that laid the groundwork for the computer revolution are highlighted, including: Samuel Morse's electric telegraph (1840s); Thomas Edison's early light bulbs (1880s), and the voltage experiments that inspired vacuum tubes at the heart of early computers; and a punched card machine (1890s), the analog data system used in early corporate accounting as well as for the launch of the U.S. Social Security Administration.

The exhibition considers the evolution of civilian computing following World War II-era military research, including IBM's Selective

Sequence Electronic Calculator (1948). A massive machine covered with switches and blinking lights, the SSEC was developed by astronomer Wallace Eckert of Columbia University to track the positions of planets and moons. Great leaps were made in the 1950s-'60s through the development of customizable mainframe computers, storage devices, and programming languages. COBOL, initiated by Grace Hopper and the Defense Department, and FORTRAN, invented under John Backus at IBM, fueled the development of flexible business machines powered by customizable software. An IBM System/360 (1964) is exhibited as a prime example, with its evolutionary principles fully realized in a nearby example of the IBM 5150 Personal Computer (1981) that became ubiquitous on desktops across America.

Today's wired world depends on a global communications network with historic roots in New York. Throughout the twentieth century, New York-based AT&T and its Bell Laboratories pioneered the

communications technology and infrastructure behind today's Internet: digital phone lines, fiber optic cables, and satellites. Thanks to the Nobel-prize winning work of John Bardeen, William Shockley, and Walter Brattain, Bell Labs unveiled the transistor in 1947, which fueled technological miniaturization, portable devices (like radios), and, eventually, the microchip. An original Telstar 1, the satellite that provided the first live transatlantic television feed on July 23, 1962—providing views of the Statue of Liberty, Brooklyn Bridge, New York Harbor, and the Eiffel Tower—is installed from the gallery's ceiling. AT&T's Picturephone 2 Model, a precursor to Apple's FaceTime, is on display with photographs of the "see-as-you-talk" conversation between Lady Bird Johnson, the nation's first lady, in Washington and Mayor Robert Wagner in New York.

The worlds of art and computing intersected in New York, inspiring creative experimentation

About the Exhibition *continued*

on all sides. This exhibition section, *Crossroads of Art and Technology*, features an immersive landscape of video art from the 1960s projected inside a geodesic dome. Works on view include Bell Labs engineers' collaborations with Robert Rauschenberg, Lillian Schwartz, and Stan VanDerBeek, uniting New York's role as a computing pioneer with its preeminence in the art world.

The relationship between creative and technological forces is further considered in *The Business of Computers*, a section dedicated to identity, branding, and design. New York, home to both Wall Street and Madison Avenue, took center stage in the transformation of computers from laboratory tools to consumer products. Under both Thomas Watson, Sr., and Thomas Watson, Jr., IBM developed a strong and recognizable identity that married its technical innovation with Madison Avenue savvy, as seen through its *THINK* magazine

and other slogan-adorned ephemera and examples of its iconic advertisements and product packaging designed by Paul Rand. Specimens such as IBM's iconic Selectric typewriter—designed by Eliot Noyes, who also supervised IBM's consumer-oriented industrial design program—are available for visitors to try at the exhibition's typewriter “bar.”

The exhibition's next section, *Media Machines*, illuminates New York's pioneering role in developing the graphics, music, and games that have transformed the way we perceive and interact with the world. Computerized musical instruments invented by Bell Labs engineer Max Mathews—whose work inspired HAL 9000's musical solo “Bicycle for Two” at the climax of the iconic movie *2001: A Space Odyssey*—are also displayed, including the groundbreaking electronic violin Mathews first wired to a computer and wrote software for in 1957. A recreation of the Tennis for

Two Electronic Game—designed in 1958 by Nobel Prize-winning physicist William A. Higinbotham at Brookhaven National Laboratory on Long Island—looks back to the true genesis of video games. The rise and decline of 1970s–'80s video game arcades in New York are commemorated with a playable 1978 Space Invaders game in its original cabinet.

Although the computer industry shifted attention to the West Coast beginning in the 1980s, New York remained a vibrant center of technology and today a citywide resurgence is underway. The exhibition closes with *Regaining the Spotlight*, a high-energy media presentation that celebrates New York's spirit of innovation, maps the growth of technology companies based in the city's neighborhoods, and presents the stories of key thinkers and entrepreneurs who helped ignite New York's digital renaissance.

Classroom Notes

About the Curriculum	8
How to Navigate	8
Materials in the Curriculum.....	9

Classroom Notes

About the Curriculum

Like the exhibition *Silicon City: Computer History Made in New York*, this curriculum is a story of history and innovation in New York. Images in these materials reflect many of the objects and reproductions included in the exhibition. Spanning the period from the mid-nineteenth century discovery of the telegraph to the present, it is designed for middle and high school students studying social studies, technology, or visual arts.

The curriculum meets the **New York State Social Studies Framework** and the **Common Core Standards for Literacy in History/Social Studies** and for **Literacy in Science and Technical Subjects** for grades 7, 8, and 11. It also supports the New York City Department of Education's **Blueprint for Teaching and Learning in Visual Arts**.

Separate classroom suggestions are provided for **social studies**, **technology**, and **visual arts** classrooms, with additional suggestions for **cross-curricular activities**. Throughout these materials, you will find layers of questions you can use to help students explore them. You may not wish to pose all these questions for your students, but understanding how they function will help you make choices.

Worksheet questions will help students look carefully at an individual image or excerpt, and hone their skills in examining primary materials. In addition to the two **worksheets** designed for technology classrooms, two more are provided to help students examine primary materials, both images and text. These can be used across disciplines with Resources 1-10. (Resource 11 is not a primary source.) In order to answer these worksheet questions, students need to look very closely at the details in the image or text, so it will be necessary to provide them with the enlarged image in the **printable resources**.

Guiding questions, included on the description pages for all the numbered resources and life stories, help students identify the main points and assess the significance of each item after analyzing the source and reading the resource description.

Discussion questions within the suggested activities help students discuss their learning and reflect on the links between the activity and their own lives.

These classroom materials are designed for maximum flexibility in the classroom. They can be used collectively, individually, or in various combinations to support existing topics in your curriculum. Please feel free to make use of these materials in whatever way works best for your classroom.

How to Navigate

The curriculum is easily navigable. All classroom materials can be reached from the table of contents and from Silicon City: A Timeline. To return to the table of contents from any page, click on the page number in the lower corner. To return to the timeline, click on  from any main resource page. Individual materials can also be reached from the following chart and from the many live links within the text.

All relevant visual resources are included at maximum size in the collection of printable resources. These printable resources allow your students to see details more clearly, and to examine a resource without the aid of descriptive text. To reach an individual printable resource, click on the **image** on the main resource page.

Resource 11: A Brief History of Computer Graphics: Made in New York is a film, which can be found on the flash drive.

When printing these materials, please use the fit-to-page setting.

Classroom Notes

Materials in the Curriculum

TIMELINE

★ **Silicon City: A Timeline.** Briefly covers New York-based developments from the 1840s to the present.

RESOURCES

1: Hollerith's Electrical Tabulating Machine (image)

An 1890 *Scientific American* cover showing the tabulating of the U.S. Census.

2: Punched Cards (image)

Samples of the cards that dominated data processing from 1890 to the 1960s.

3: The Three Laws of Robotics (text)

Isaac Asimov's rules to prevent fictional robots from killing their human creators.

★ **4: Women Programmers of ENIAC** (image)

Women programming an early computer, before programming became a mostly male field.

5: The Transistor (image)

The Bell Labs invention that replaced vacuum tubes and led to small, powerful computers.

6: Walter Cronkite and UNIVAC (image)

The first use of a computer on television, on the night of the 1952 presidential election.

7: The First Transatlantic Telephone Cable (image)

AT&T's undersea line, the first step in today's global communication system.

8: The IBM Pavilion at the World's Fair (images)

Many visitors' introduction to the computer age.

9: Design and Branding (images)

IBM's approach to design changes its public image, and the field of industrial design

10: Watson on Jeopardy! (image)

The public face-off between IBM's "Watson" and the two biggest winners on TV's *Jeopardy!*

11: A Brief History of Computer Graphics: Made in New York (film)

A five-minute film about the origins of computer-generated imagery at Bell Labs and the New York Institute of Technology.

LIFE STORIES

Samuel F. B. Morse (1791–1872), inventor of the telegraph and Morse code, the dot-dash language that anticipated binary computer code.

Thomas A. Edison (1847–1931), whose discovery of the "Edison effect" led to the development of vacuum tubes essential to early computers.

Herman Hollerith (1860–1929), inventor of the punched card tabulator used in the 1890 U.S. Census, and founder of one of the companies that ultimately became IBM.

★ **Grace Hopper (1906–1992)**, a pioneering early programmer and co-inventor of the COBOL computer code.

Thomas J. Watson, Sr. (1874–1956) and Thomas J. Watson, Jr. (1914–1993), the father and son who led IBM for more than six decades.

APPENDIX

Writing Numbers in Binary: An Infographic

A Computer in Your Pocket: An Infographic

Predicting 2015—High School Essays from 1965

★ **Silicon City Now.** A diverse gallery of New Yorkers working in technology today.

Glossary

Books and Websites

Source Notes

Standards

WORKSHEETS, INFOGRAPHICS, AND PRINTABLE RESOURCES

Suggested Activities



Pre- and Post-Visit Activities..... 11

Social Studies Activities..... 13

Cross-Curricular Activities 19

Technology Activities..... 23

Visual Arts Activities..... 29

Suggested Activities

Pre- and Post-Visit Activities

Morse Code: Pre-Visit or Introductory Activity

Morse code was created by telegraph inventor Samuel F. B. Morse and his business partner, Alfred Vail, in the 1830s. It is a system for translating digital data (the on/off electrical pulses of the telegraph) into human language (the alphabet).

A basic familiarity with the dots and dashes of Morse code will help students understand the digital language of today's computers, which also store and process data as a series of on/off pulses—and which also must translate those pulses into words or images. To introduce it, distribute copies of the Morse code chart (<http://morsecode.scphillips.com/morse2.html>, and elsewhere online), or show it on a Smart Board. Give students time to examine it. Then, ask them to listen as you send a message either by clapping your hands or tapping a surface. Make

the message very short, either a single letter, or a short word, like “if” or “the.” Work slowly so students can use the chart to decode it. Then ask them to work in pairs, and send each other a message by clapping or tapping the code.

Use this site, www.morseresource.com/morse/makemorse.php, to enter a phrase and hear it converted to Morse code at different speeds. Let students listen to a message at the fastest speed, to help them appreciate how quickly skilled telegraph operators could decode a message.

For an **alternate pre-visit activity**, see **How Computers “Think,”** in which the teacher plays the computer, the students play the programmers, and the task is to make a peanut butter and jelly sandwich.

Predicting the Future: Post-Visit or Wrap-Up Activity

The first section of the exhibition is focused on the IBM Pavilion at the 1964 World's Fair in Queens, where many visitors had their first glimpse of the dazzling new world of computers. After seeing the Fair, Isaac Asimov wrote an essay called “Visit to the World's Fair of 2014,” published in the *New York Times* on August 16, 1964, www.nytimes.com/books/97/03/23/lifetimes/asi-v-fair.html.

Asimov was a noted scientist and science-fiction writer. In this article, he wrote about his own reactions to the IBM and other industrial pavilions, and he tried to imagine what the World's Fair, and the world, would be like in fifty years. Ask students to read the essay.

Next, ask students to **read two essays written by ninth-grade students in 1965** for a contest entitled “New York's Future As I

View It.” Asimov and the student essay writers were trying to imagine the world we live in today. Ask students to select one of the three essays and write a response.

- * What was the earlier writer correct about?
- * What was the writer wrong about?

Students should mention some of the things about today's world that might be surprising to Asimov or one of the students. They should include their own predictions for fifty years in the future, about what homes, transportation, and entertainment will be like in 2065, based on what they have learned about technological developments from *Silicon City*. Students should think about what they hope will happen, and what they fear will happen. (For population figures today, go to <http://www.census.gov/popclock/>.)

Suggested Activities *continued*

Social Studies Activities

LS



R1



R4



SCN



★ Diversity in Technology

To help students understand how attitudes about, and opportunities for, women and minorities in technology have changed over time, assign the life story of **Grace Hopper** as well as **Resource 1: Hollerith's Electrical Tabulating Machine**, **Resource 4: Women Programmers of ENIAC**, and **Silicon City Now**.

- * What patterns do students see?
- * What issues did women and minorities face at different time periods?

Ask students to Google the words *girls, technology*. Explain that Google's results are based on algorithms, and generally list the most frequently visited websites first. Ask them to study just the first page of results, and the short amount of text included with each result, and make a chart of what they find.

- * How many results does this search produce? How many appear on the first page?
- * How many results assume that girls are not interested in science?
- * How many focus on barriers to opportunities?
- * How many present a possible solution?
- * Which words or phrases (such as "inspire") communicate attitudes about girls and technology?

Suggested Activities *continued*

Social Studies Activities

Diversity in Technology *continued*

Ask students to write an analysis of their charts. (This can also be done as a classroom discussion.)

- * What are the prevailing attitudes about girls' interest in science and technology?
- * What solutions are suggested?
- * How does their analysis compare with their own experience, or that of their friends?

Ask students about their personal experiences.

- * How comfortable do they feel with technology? If they are girls or members of a minority, is that a factor?
- * Ask them to interview adults they know who have jobs related to computer technology. What have their experiences been? Have they encountered bias as women or minorities? How have they handled it?
- * What do they think needs to happen to make technology more inclusive?

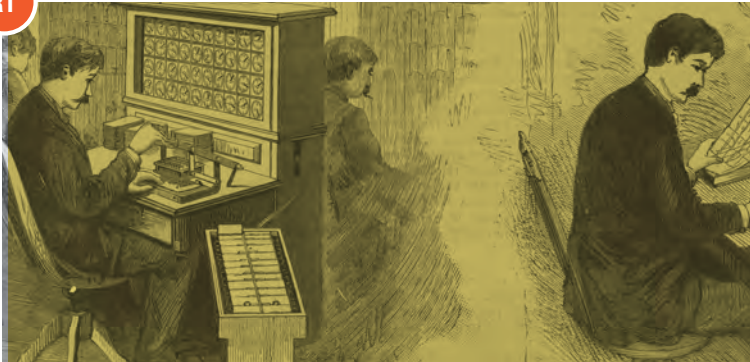
Suggested Activities *continued*

Social Studies Activities

LS



R1



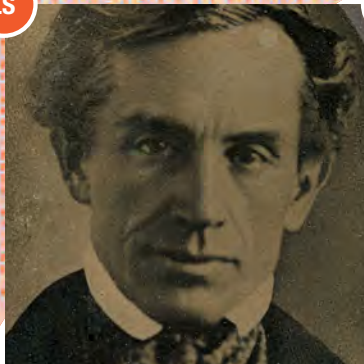
Classroom Census

The 1890 U.S. Census presented a mountain of data, which Hollerith's new tabulator analyzed far more efficiently than human clerks could have managed. (See the life story of **Herman Hollerith** and **Resource 1: Hollerith's Electrical Tabulating Machine**.) The U.S. Census is still one of the great challenges of data collection and processing.

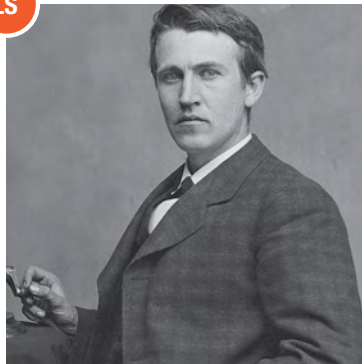
To help your students explore what's involved, go to a website called Census at School, www.amstat.org/censusatschool/about.cfm. In this project, students conduct a census of their classroom, analyze the results, and compare them with a statistical database of other classrooms in the United States, Africa, Asia, and Europe.

Census at School is designed for middle and high school students. It originated in the U.K. in 2000. The U.S. part of the program is hosted by the American Statistical Association.

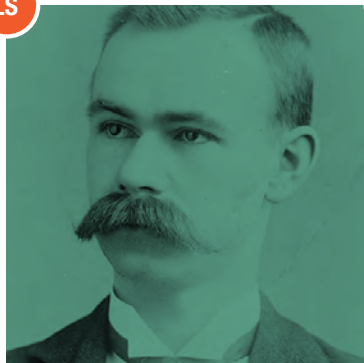
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LS



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LS



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Suggested Activities *continued*

Social Studies Activities

Childhood and Education

To understand how childhood experiences affected the lives of key players in the history of technology, ask students to work in five small groups, and assign each group a different life story: **Samuel F. B. Morse**, **Thomas A. Edison**, **Herman Hollerith**, **Grace Hopper**, or **Thomas J. Watson, Sr. and Thomas J. Watson, Jr.** Ask each group to read the life story together and answer four questions about the subject's childhood:

- * How would you describe his or her personality as a child?
- * What talents or skills emerged in childhood?
- * How did the person's family support his or her interests?
- * What was the person's formal education?

Compare all the groups' findings in a class discussion.

- * In what ways were these life-story subjects similar as children?
- * What helped them succeed?
- * How do people your age learn about technology?
- * What role does school play?
- * What skills do students have today, and how do they learn them?

TL



LS



R1



R5



R6



R7



Suggested Activities *continued*

Social Studies Activities

Technological Breakthroughs From Industrialism Onward

To help students understand what's behind big technological innovations, ask them to read at least two of the following: **Silicon City: A Timeline**, the life stories of **Samuel F. B. Morse**, **Thomas A. Edison**, **Herman Hollerith**, **Grace Hopper**, the **Watsons**, **Resource 1: Hollerith's Electrical Tabulating Machine**, **Resource 5: The Transistor**, **Resource 6: Walter Cronkite and UNIVAC**, and **Resource 7: The First Transatlantic Telephone Cable**.

In a class discussion, focus on where breakthroughs come from. Ask students to present evidence from the text and/or images in their answers.

- * How did the age of industrialism lead to today's digital world?
- * What factors lie behind the success of these individuals (such as perseverance, luck, group effort, necessity, pure flashes of insight)?
- * Which factors matter most?

Ask students to make a timeline of changes they have observed in their own lifetimes. They can focus on whatever they wish—cell phones, apps, video games, etc. Their timeline should include dates (or approximate dates) and a brief description, as well as images. They can produce their timeline digitally, and drop in images from the Internet to illustrate their point.

- * How does the timeframe of change they've witnessed compare with the rate of change in earlier decades—to the telegraph, for example? Does change happen faster today? If so, why do you think that's the case?

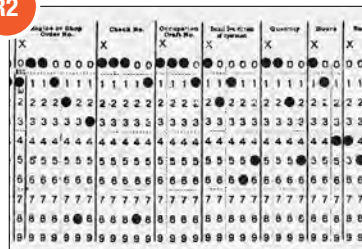
Suggested Activities *continued*

Social Studies Activities

LS



R2



R6



R8



R9



R10



SCN



Selling Technology

To help students understand the role played by New York and IBM in spreading awareness of, and enthusiasm for, computers, use the life story of the **Watsons**, **Resource 2: Punched Cards**, **Resource 8: The IBM Pavilion at the World's Fair**, **Resource 9: Design and Branding**, and **Resource 10: Watson on Jeopardy!**.

- * How did IBM become prominent? How did it use its corporate identity to sell computers and the idea of computers?
- * Do ads and logos matter to students today? How do they decide what they want to spend their money on?

Attitudes About Technology

To help students explore attitudes about technology over time, assign **Resource 3: The Three Laws of Robotics**, **Resource 6: Walter Cronkite and UNIVAC**, **Resource 10: Watson on Jeopardy!** and **Silicon City Now**.

- * What attitudes about technology are stated in these resources? What attitudes are unstated? How have attitudes changed and how have they remained the same? Why do you think that is?
- * How do you feel about the technology in your own life? Do you ever worry about spending too much time on it?
- * How do the adults around you feel? Do they set rules for which sites you can visit, or how much time you can spend in front of a screen? Would you do the same if you were a parent?

Suggested Activities *continued*

Social Studies Activities

★ Research Project

Using online and printed sources, research the life of Ada Lovelace. Write a paper that compares her with **Grace Hopper**, focusing on their lives, education, contribution to the history of computers, and reputations.

★ Discussion Questions

- * What's the best way to make employment in technical fields more diverse? Why is it a good idea?
- * How have cell phones, smart phones, and computers changed the way people interact? Is it a change for the good? Do you and your friends use technology differently from older people you know?
- * How do technological developments relate to what we think of as history? For example, how did the laying of the transatlantic cable in 1956 reflect both postwar optimism and Cold War fears? (See **Resource 7: The First Transatlantic Telephone Cable.**)
- * How did the rise and fall of opportunities for women reflect the broader history of women in America since World War II?
- * What's it like to study an era you're part of? How different is it from studying past events, like nineteenth-century industrialism? How does studying the present change how you understand the past?
- * How do the people working in the New York technology world today (see **Silicon City Now**) compare with historic figures students have met in this curriculum? What has changed? What has remained the same?

Suggested Activities *continued*

Cross-Curricular Activities



Resource 11, a five-minute film entitled *A Brief History of Computer Graphics: Made in New York*, is an opportunity for students to explore the intersections of history, art, and technology. Have students watch the film and then discuss it as a class, addressing how CG (computer-generated imagery) has changed over time, how it has changed the film industry, and what made these changes possible. Then select from the activities below those that will work best in your classroom.

Starting with Edison

Ask students to read the life story of **Thomas A. Edison**, inventor of—among over 1,000 patented creations—the movie camera and the viewer people used to watch the films. Then, ask them to explore some of the early Edison films at the Library of Congress: www.loc.gov/collections/edison-company-motion-pictures-and-sound-recordings/?fa=original-format%3Afilm%2C+video#. There are 332 films at this site, and they vary in length. You might want to assign them to your students so as many films as possible are seen by your class. As they watch, ask them to consider these questions:

- * During what years were the films made?
- * What did the films show? How would you describe them? Are they fiction? Nonfiction? Comedies? Dramas?
- * If you watch them chronologically, how do they change over time?
- * How do the films compare to other technological changes brought about by industrialism?

Early Animation

Thomas Edison did not invent animation, but the popularity of his films and movie equipment opened the door to animated films. One of the earliest was *Gertie the Dinosaur* (1914), <https://archive.org/details/Gertie>. Made by cartoonist and animator Winsor McCay, this twelve-minute film is set in the American Museum of Natural History, located on Central Park West in New York City. Ask students to watch the film and answer these questions:

- * How would you describe the film?



Suggested Activities *continued*

Cross-Curricular Activities



- * How is it different from the early Edison movies?
- * Compare it with recent films you've seen. What similarities and differences do you see?

A Timeline of Animation

Many animated films, or scenes from them, can be viewed online. Ask students to watch some of these clips and make a timeline of animated films, from *Gertie the Dinosaur* to *Toy Story*:

Gertie the Dinosaur (1914): <https://archive.org/details/Gertie>.

Snow White and the Seven Dwarfs (1937), the first feature-length animated film:
<http://movies.disney.com/snow-white-and-the-seven-dwarfs>.

Gumby (1950s), a series of claymation films:
www.gumbyworld.com/gumby-pokey-episodes/1950s-overview.

Wallace and Gromit (1990s), a British claymation series available at:
www.youtube.com/watch?v=YC-MR84S1H8.

Trailers of many Disney animations can be viewed at
www.disneymovieslist.com/animated-disney-movies.asp.

Ask students to study their timeline and answer these questions:

- * How have animated characters changed over time?
- * What changes do you notice in animation technique or technology?
- * Which audience are most animations designed for?
- * What do you think is the major difference between *Toy Story* and the animations that came earlier?

Suggested Activities *continued*

Cross-Curricular Activities

Character Creation

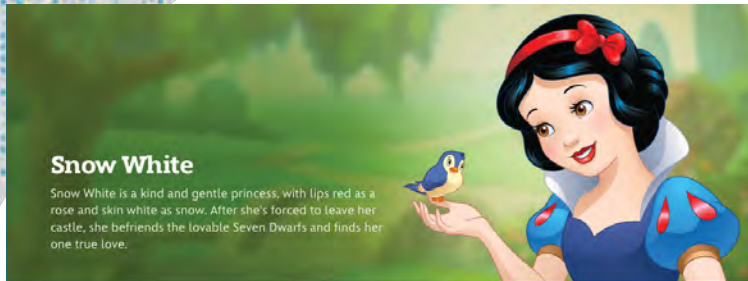
Animators are inspired by their surroundings. Show students examples of concept designs for the *Toy Story* characters at www.pixar.com/features_films/TOY-STORY#Title, or watch this clip about character design in *Monsters, Inc.*: www.pixar.com/behind_the_scenes/Character-Design#.

Woody and Buzz from *Toy Story* are beloved toys, not only to their owner, Andy, but to audiences as well. It takes many attempts to create successful, memorable characters. Invite students to create an animated character of their own using mixed-media art (colored pencil, pastel, collage, or even clay). Have students create three different concept designs for their character, each with its own unique features and personality.

Comparing *Snow White* and *Toy Story*

Ask students to watch **Resource 11: A Brief History of Computer Graphics: Made in New York**, and compare it with two short films about the making of *Snow White* (<http://video.disney.com/watch/the-big-gamble-4bb39cc2c1af5a8833003b15>) and *Toy Story* (www.pixar.com/features_films/TOY-STORY#Title/video/3761).

- * What role did hand drawings play in each film?
- * What roles were played by the visual artists working on *Snow White*? On *Toy Story*?
- * What tools and technology can you see artists using to make *Snow White*? What skills did they need?
- * What tools and technology can you see artists using to make *Toy Story*? What skills did they need?
- * What do differences in skills between the artists working on the two movies indicate about their training? What do they tell you about how computer technology has changed the field of animation?



Suggested Activities *continued*

Cross-Curricular Activities

Filming an Animated Short

To experience the act of animating a subject, students can develop a stop-motion short film. Students can use the hand-drawn character they created in the Character Creation activity. Three-dimensional props (i.e., small toys or action figures) can be used as an alternative.

Have students begin by creating a four-frame visual storyboard on paper that outlines the plot, setting, and dialogue. Once they have their scene planned, they can design their backdrops, make props, or create additional character illustrations before filming.

Students can use one of the following tablet apps to make their scenes come to life:

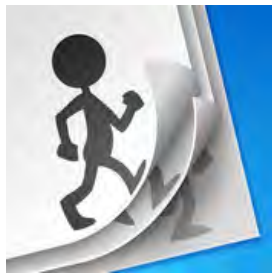
- * StopMotion Recorder
- * FlipBook
- * ABCya! Animate

Discussion Questions

- * How did available film technology affect what people were able to see in Edison's time? How does the technology available today affect what you are able to see?
- * How do you think the films you see affect your sense of the world? Your imagination? Your expectation of popular entertainment?
- * How has the use of CG (computer-generated imagery) changed the movies you see? What do you like or dislike about CG's role in films today?
- * Animated films are part of our popular culture. Why do you think they're aimed mostly at children? How do you think they affect how children think and feel? What animated films made a lasting impression on you? Did you watch them repeatedly because video or DVD technology made this possible? What did you like about them?



<https://itunes.apple.com/us/app/stopmotion-recorder/id373313019?mt=8>



<https://itunes.apple.com/us/app/flip-book-lite/id287440835?mt=8>



<https://itunes.apple.com/us/app/abcya-animate/id682094850?mt=8>

Suggested Activities *continued*

Technology Activities

Ben Samuels-Kalow, Laboratory School of Finance and Technology

Activity 1: How Computers “Think”

Part 1: PB&J

Materials

Ingredients for a PB&J sandwich: bread, peanut butter, jelly, a knife or spoon.



Overview

In these activities, students will learn that a program is a set of instructions for a computer to follow in a particular order.

Students will see that functional code is made of sequen-

tial and specific steps, and will gain experience debugging (fixing) code, an essential skill for programmers.

Rationale

How often have you heard someone say that a piece of technology “doesn’t want to work”? We all use some kind of technology every day, but most of us don’t understand that a machine has no *wants*—it only follows the instructions of its imperfect human programmers.

Unplugged Activity (no computers required)

This is a classic activity to introduce basic computer science to students. This will be a simulation of how a computer works. The teacher will be a “computer,” programmed by students.

Ask students to write down the steps needed to make a peanut butter and jelly sandwich. They’re in the role of programmers. Your job is

to follow their instructions. You play the computer.

This works best if you are extremely literal. Your goal is to guide students to understand that their instructions must be specific and sequential. If a student writes, “Put the peanut butter on the bread,” take the entire jar and place it on top of an unopened loaf of bread. Why? The programmer skipped several steps: unscrewing the lid, getting a utensil, removing a specific amount of peanut butter, spreading it on the bread, etc. Students will laugh, and they will start to change how they give directions.

Allow them to rewrite the instructions, checking with a partner. Students must read directions to you exactly as they wrote them. If their instructions have unintended consequences, that is precisely the point. Draw out the process for about 10-15 minutes. For the

final round of instructions, try a round-robin, in which students can give one command, and then pass responsibility for the next command to another student. This increases class participation, and again emphasizes the essential concepts of being **specific** and **sequential**.

Make sure students understand that:

- Computers follow a set of instructions called a **program**.
- Programs are written in **code**.
- Code can be written in many languages.

Discussion

Ask students to think about and discuss the following:

- * What are you better at than a computer?
- * What is a computer better at than you?
- * What does a computer lack that you have?

LS



R1



R4



Suggested Activities *continued*

Technology Activities

Ben Samuels-Kalow, Laboratory School of Finance and Technology

- * What did you notice about how we gave instructions at the beginning of class compared with how we gave instructions after the activity?
- * Why do you think that mattered?

Part 2: The Growth of Programming

Resources

- Life Story of Grace Hopper
- Resource 1: Hollerith's Electric Tabulating Machine
- Resource 4: Women Programmers of ENIAC
- Resource 5: The Transistor

Explain to students that the way we programmed the peanut butter and jelly process—painstaking and slow—is not all that dissimilar from early programming. Through trial and error, and an ever-more-specific sequence of tasks, we accomplished a goal and made a peanut butter and jelly sandwich. Early programming was tedious and error-prone, and efficiency

was only realized after long practice.

Tell students that as we made our instructions better, we were engaging in what programmers call debugging. ★ Have students read the life story of **Grace Hopper** to learn the etymology of this word as well as the work of early programmers and women's central role in mid-century computer programming. Debugging gets to the heart of programming. It is an iterative process, one in which improved results are realized by doing something over and over again, trying new solutions and encountering new failures, in the pursuit of new successes.

Have students analyze **Resource 1: Hollerith's Electrical Tabulating Machine**. This is one of the first examples of a computing machine.

- * What parts of the cover look familiar as a “computer”? What parts seem strange? (*Examples of*

possible responses are: “There are devices like keyboards,” “But there are no screens,” or “They put paper into the machine instead of getting paper out like we do now.”)

- * How does the machine “know” what to do? How could this “code” go wrong? What errors could be made?

Contrast with **Resource 4: Women Programmers of ENIAC**. Ask the same questions:

- * What looks familiar, like the computers of today?
- * How does the computer “know” what to do (how is it given instructions)?

Both of these early computing machines required the programmer to arrange hardware in order for the computer to carry out instructions. Today, programmers mostly work with software and create that software, not by arranging tubes or holes in cards, but by typing letters and numbers with very

strict conventions, so that a computer can understand a programmer's instructions.

How did that change happen? Introduce **Resource 5: The Transistor**. Have students analyze the image and read the resource description. What was so revolutionary about transistors? Having many tiny “switches” meant that instead of being the size of a room, a computer could be the size of a desk, and then a book, and then a pack of cards, and then a watch ... and so on.

Reflection (Discussion or Writing)

Admiral Grace Hopper said programming is “just like planning a dinner. You have to plan ahead and schedule everything so that it's ready when you need it.”

- * What do you think Dr. Hopper meant?
- * How did computer programming change over the course of the twentieth century? How quickly or

Suggested Activities *continued*

Technology Activities

Ben Samuels-Kalow, Laboratory School of Finance and Technology

slowly did those changes happen?

- * Who were some central figures in the development of different coding languages?
- * Based on your experience today, what skills do you think are important to program a computer?

Plugged-In Activity: Programming Extension 1

Have students sign up for Codecademy (www.codecademy.com/), a free website with tutorials in many languages. Codecademy offers a variety of courses and has options to create classes and monitor student work, if you wish to use it for longer periods of time in your classroom.

Select the exercise called “Animate Your Name.” In this exercise, students are going to get a hands-on, step-by-step introduction to coding, which will culminate in a finished

product. “Animate Your Name” uses HTML, CSS, and JavaScript, the three most common languages used to create websites. It’s a good idea to go through the course yourself. It should take less than an hour.

Students are introduced to and are asked to use a few essential programming concepts: variables, conditionals, and functions. The website has excellent copy (and is available in a variety of languages).

Students will see that (most) modern computer code is typed, using the alphabet we know, but in languages we may not.

After students have experienced coding, have them again look at **Resource 1: Hollerith’s Electrical Tabulating Machine** and **Resource 4: Women Programmers of ENIAC**.

- * What are the advantages of modern coding languages?

Draw attention to this excerpt from the ENIAC resource:

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 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.”

- * Did you have to “know” math in order to get the computer to do math? Why or why not?
- * Did you have to “know” anything about the inside (hardware) of your computer in order to give it instructions (software)? Why or why not?

Activity 2: How Computers Store and Display Information

Resources

- **Resource 2: Punched Cards**
- **Resource 4: Women Programmers of ENIAC**
- **Resource 5: The Transistor**
- **Life Stories**
- **Binary Worksheet**
- **Binary Run Length Image Encoding Worksheet**
- **Writing Numbers in Binary: An Infographic**

Overview

This activity guides students from a relatively difficult concept (working in binary/base 2) to an important conceptual understanding (all modern computers rely on binary) to an applied understanding (binary is the way a computer can store information).

Rationale

Pretty much everyone has seen something like this

R5



Suggested Activities *continued*

Technology Activities

Ben Samuels-Kalow, Laboratory School of Finance and Technology

used as a way to depict the ineffable mysteries of what happens inside a computer:

01101001 01100110 00100000
01111001 01101111 01110101
00100000 01100100 01100101
01100011 01101111 01100100
01100101 01100100 00100000
01110100 01101000 01101001
01110011 00101100 00100000
01100101 01101101 01100001
01101001 01101100 00100000
01100010 01110011 01101011

This lesson will make those mysteries a little less mysterious.

Unplugged Activity (does not require computers)

Have students fill in Chart 1. To introduce the importance of the on/off signal in computers, ask students to do the following exercise.

Count to three in your head. You just did something that

no computer, not those in the *Silicon City* exhibition, nor the smart phone in your pocket, can do. Computers operate on electricity, and electricity is either ON or OFF. In computer science, we call that binary, meaning “two options,” and use 0 for OFF and 1 for ON. Everything your computer does begins with 1s and 0s, flicking on and off.

ten options (0, 1, 2, 3, 4, 5, 6, 7, 8, 9), we only have two (0, 1). So, how do we write “one” in binary? Easy: 1. But what about “two”? Well, that’s where we have to understand how “powers” of two work. We need 1 two and 0 ones to make two—so in binary, two is 10.

See Chart 3 to help us out.

Nine in binary is 1001: one 8 + one 1 = 9.

Let’s practice using the **Binary Worksheet**.

Every instruction a computer follows can be reduced to a sequence of ON’s or OFF’s. In computer science, we refer to each individual binary digit (the one or the zero) as a bit. A group of eight bits is called a byte, and can store the numbers between 1 and 255. Have you ever seen the word “byte” before—like megabyte (a million bytes) or gigabyte (a billion bytes)?

Chart 1.

$2^7=$	$2^6=$	$2^5=$	$2^4=$	$2^3=$	$2^2=$	$2^1=$	$2^0=$

Chart 2.

Number	1000 column (10^3)	100 column (10^2)	10 column (10^1)	1 column (10^0)
8				8
18			1	8

Chart 3.

Number	8 column (2^3)	4 column (2^2)	2 column (2^1)	1 column (2^0)
1	0	0	0	1
2	0	0	1	0
8	1	0	0	0
9	1	0	0	1

How does binary work?

In everyday life, we count in what’s called “base 10” or “decimal.” Count from one to nine. What happens next? Ten, of course. Ten (10) is made of the digits “1” and “0.” It means you have one 10, and zero 1s. That works until you have nine 10s and nine 1s (99). But now what? 100, of course: one 100, zero 10s, zero 1s. Each time, you use another multiple of ten, and gain another column. (See Chart 2.)

Binary works in a similar way, but instead of having

R5



These terms refer to the size of information: the more 1s and 0s a chip has, the more complex information it can store and manipulate.

Hands on with Binary

What can we do with just a few bits of information? Well, like early computers, we can display very simple black-and-white pictures. Once you've gone through this activity, you'll see that even displaying black-and-white pictures is complicated. (Imagine what your beautiful color display is doing right now!)

If you looked at this document on screen very closely, it would look like this. ▼

look like this.

Suggested Activities *continued*

Technology Activities

Ben Samuels-Kalow, Laboratory School of Finance and Technology

Each of those little squares is a pixel—a little bit of light on a screen which, when lit, can form a picture of anything. We're going to learn how to turn binary information into pictures using pixels with the **Binary Run Length Image Encoding Worksheet**.

Reflection

Ask students to describe their method to convert decimal numbers into binary, and from binary into decimal.

- * What are we better at than a computer?

Silicon City Curriculum Resources

Have students examine and discuss **Resource 4: Women Programmers of ENIAC**.

- * What does ENIAC have in common with computers that students use? What is different?
- * Big hint: ENIAC has no screen! As simple as our pictures are today, the ability to display *any*

information on a screen at all was a huge advance in technology.

Turn to **Resource 5: The Transistor**. What's happening inside a transistor is a miniaturized version of what happened in the image encoding worksheet. We turned "pixels" on and off by shading in boxes. The transistors that make modern computers possible work just like a switch. They control the pixels turning on and off in your screen, but they also control every decision made inside your computer. The software that runs our computers is very, very long sequences of ON's and OFF's. Instead of making those physically switch ON and OFF using tubes or wires, the transistor either has a voltage or it does not.

Look back to **Resource 1: Hollerith's Electrical Tabulating Machine**. What represented ON and OFF in this machine? (Holes, or

not, in the punched cards.) The transistor took this idea—breaking information into ON's and OFF's to be calculated quickly by a machine—and allowed it to be miniaturized and sped up. Thanks to the transistor, you never have to flip a switch to give a computer instructions—you can use a mouse, a keyboard, and a screen.

Plugged-In Activity: Programming Extension 2

Have students sign up for Scratch (<https://scratch.mit.edu/>). Scratch is a language designed to teach students programming using blocks (instead of typing code). Scratch allows for the creation of animations, stories, and interactive projects. It allows students to import images as "sprites" and animate them, controlling a story using code. The finished project is somewhere between an animated PowerPoint and a video game, and the

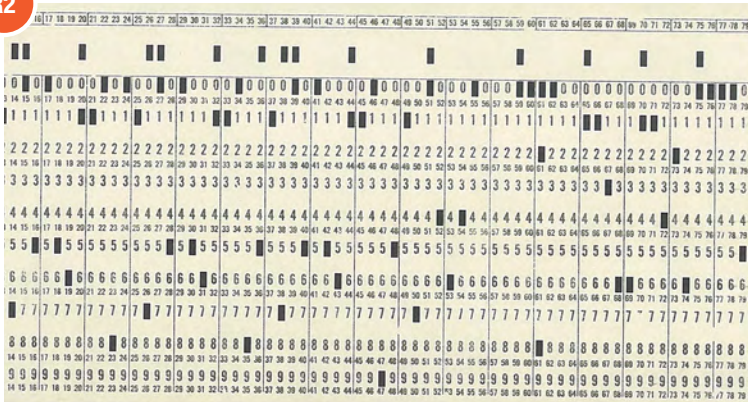
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creative process draws on programming skills, presentation skills, and creative writing skills.

In this activity, students will code a story or interactive project that explores key concepts from the exhibition.

R2



Suggested Activities *continued*

Technology Activities

Ben Samuels-Kalow, Laboratory School of Finance and Technology

Have them choose from the following:

- **Resource 2: Punched Cards**
- **Resource 4: Women Programmers of ENIAC**
- **Resource 5: The Transistor**
- **Life stories of Samuel F. B. Morse; Thomas A. Edison; Herman Hollerith; Grace Hopper; Thomas J. Watson, Sr., and Thomas J. Watson, Jr.**
- **Writing Numbers in Binary: An Infographic**

Using Scratch, have students code an animation that explains the significance of their selected innovation or innovator. If students choose a technology from **Resource 2**, (punched cards), **Resource 4** (ENIAC), or **Resource 5** (the transistor), encourage them to use the Scratch animation to *show* an audience how that technology works. Creating the animations requires student to think specifically and sequentially—the same skills they will need for any kind of coding.

If students choose a life story, encourage them to seek images and anecdotes outside the resources.

As an extension, ask students to create a project that connects multiple resources (e.g., the life story of the **Watsons** with “Watson,” the supercomputer, or an animated timeline that connects multiple items from the resources).

If students have completed both activities, ask them to reflect on the following:

- How were the unplugged activities (PB&J and binary) similar to programming? What did they have to keep track of in both?
- How is Scratch similar to typing code (Programming Extension 1)? How is it different?

Suggested Activities *continued*

Visual Arts Activities

Maggie Chang, Fiorello H. LaGuardia High School of Music & Art and Performing Arts

Activity 1: Rebranding Campaign: Modern Company Makeovers

Part 1: Company Identities Resources

- **Resource 9: Design and Rebranding**
- **Life story of Thomas J. Watson, Sr., and Thomas J. Watson, Jr.**

Procedure

The recommended resources capture how rebranding strategies helped IBM become and remain successful. Ask students to read these materials and answer the following questions to establish an understanding of a company's *brand*, its *identity*, and the difference between the two.

Brand:

- * How might you describe the personality of IBM? What do you think the company valued? How do you know?
- * Explain that *branding* relates to how a company wants a consumer to feel about it based on its personality and values. (*Do you trust the company? Do*

you feel like supporting it by becoming its consumer?)

- * Think of examples in which different people's personalities and values impact how you feel about them.

Identity:

Explain that a company's *identity* relates to the visual aspects that form the brand, including a logo.

- * From the resources, which visuals led you to see IBM's personality and values the way that you do? (*Answers should include visuals observed in resource images, such as colors and shapes, as well as visuals imagined based on the text, such as Watson, Sr.'s dress code and Watson, Jr.'s debut of the System/360.*)
- * How is this similar to people changing their look in order to change their identities? Why might a person or company want to do this over time?

Note: The two follow-up

exercises serve as parts of one rebranding campaign activity. They were designed to work as a pair, but can be done individually. The goal is to learn that thoughtful, cohesive visual communication choices can transform the way the world sees, thinks, and feels about an existing company.

Part 2: Logo Design

A company's logo should be simple so it can be immediately recognized. This exercise explores the thoughtful process behind the design of a logo—a process that is not nearly as simple as its outcome might suggest.

Ask students to select an existing company that is meaningful to them. To begin, they can create mind maps about the company. (*Start by writing the company name in the middle of a piece of paper; draw lines from the center with any words*

associated with the company and topics that come to mind; continue repeating the same process for the subtopics, expanding out to the edges of the paper, creating what looks like a map.) Students can then research the company's existing core values, which are its guiding principles such as community, diversity, and innovation. They should also research the current logo design concept and compare it with its competitors'.

Introduce the class to the concept of a *creative brief*—a designer's short, written plan that guides all design work in order to maintain cohesiveness in branding/rebranding a company's identity. Ask students to complete their own creative brief by answering in-depth questions such as the following. (*Suggestion: Model answering these questions using IBM as an example.*)

R9



LS



Suggested Activities *continued*

Visual Arts Activities

Maggie Chang, Fiorello H. LaGuardia High School of Music & Art and Performing Arts

- * What service does the company or company's product currently provide for consumers? Consider its benefits both on a practical level and an emotional level. How is the company currently perceived?
- * How do you think the company should be perceived? By whom? Describe the target audience in detail.
- * What adjectives describe the tone or feeling this new identity expresses? What colors, fonts, symbols, and shapes might communicate those adjectives?

Ask students to consider what simple image or symbol comes to mind that communicates the answers for their creative brief. How might they combine it with the name of the company? Students should sketch multiple concepts at this stage of the design process.

In a class discussion, ask students to think about simplicity, scalability, origi-

nality, and clarity, and why these concepts can affect the impact of a company's logo. Refer to the IBM logo from **Resource 9: Design and Branding** and other well-known successful logos (see links).

In small groups, have students answer:

- * How would you rate the success of each of these first drafts based on the criteria we reviewed?
- * What subtle variations could be made to the most successful designs?

Ask students to conclude by refining and finalizing their strongest logo design. Students can come up with a short, catchy slogan, and include this in their design as well.

Part 3: Making a Video Ad

Advertising has greatly evolved since the days of Rand, Noyes, and the Eames duo. However, the basics of design and problem-solving are still paramount, and as Tom Wat-

son, Jr., understood over fifty years ago, communicating a fresh identity requires not just changing the logo but changing the consumer experience of the company and its product. The goal of this activity is to bring this idea to life for the twenty-first century through a short 1-2 minute video ad: visual storytelling that combines moving image and sound. Students should build on the creative brief and work developed in Part 2 to maintain cohesiveness.

As a class, watch examples of ads (see links below) and ask students to consider and discuss:

- * What company values might the advertisers be highlighting?
- * Based on this ad, what service is this company offering its potential customers on an emotional level?

Ask students to consider the ideas raised from the discussion, their creative

brief, and the following questions as they develop a storyline for their own ad.

- * What does your target audience care about with respect to these products?
- * Why might the values and new identity of this company be important to the audience? Describe in detail the situations and/or struggles they are in when they might use the company's product.
- * What thoughts might push them toward becoming a consumer of this company's services or products? (*Examples of possible responses are: "Eating that will make me so much healthier" or "I have an event coming up that this would be perfect for."*)
- * What anxieties and habits might hold them back? (*Examples of possible responses are: "What if I can't figure out how to use the new one?" or "I care about the environment, but I also care about going broke."*)

Suggested Activities *continued*

Visual Arts Activities

Maggie Chang, Fiorello H. LaGuardia High School of Music & Art and Performing Arts

- * Name the emotions before, during, and after using the company's product.

Note: Because of the technical challenges of recording high-quality audio, and in order to preserve the power of storytelling through visual and musical choices, students' ads should not rely on voiceovers.

Ask students to research camera angles and the basics of storyboarding. Then, students can create their own storyboard, making sure to include a beginning, middle, and end, as well as camera angles that best communicate each of their messages. Students can also explore how music, voiceovers, and text would enhance parts of their ad.

Students can use their cell phones, cameras, or available school equipment to capture video footage, and combine them with additional elements (music, voiceovers, text, logo, etc.) in a video-editing program.

As a class, view students' complete campaigns, both logos and video ads. Ask students to self-critique how their work compares with the aims established in their creative briefs.

Discussion Questions

Some of these questions ask students to think broadly about the resources used in this activity. Others are focused on bigger questions about advertising and human nature.

- * How might IBM's commitment to design have changed the life of commercial artists?
- * What is the role of the commercial artist creating these designs and ads—one who manipulates the world's perceptions, or one who informs and educates?
- * Based on your observations, if these commercial artists hold such power, describe the people who had this power in the 1950s and 1960s.

Why might there have been such lack of diversity then? Who makes up these voices today? What has changed?

- * Ads with emotional appeal are more effective than ones that explain how a product works. What does this suggest about human nature and consumer culture? What does it suggest about why we buy the things that we buy?

For examples of video ads that have been a part of successful rebranding campaigns, see the following:

- Lego ad: Positions their product as not merely a toy but as building blocks for a strong parent-child relationship. www.youtube.com/watch?v=rwQqkX-3qZak&app=desktop
- Pantene ad: Encourages women to shine and fight negative labels. www.youtube.com/watch?v=-K2kfgW7708
- Always ad #1: Empowers pre-adolescent and adolescent girls to

transform the insult "like a girl" into something inspiring and positive. www.youtube.com/watch?v=F_Ep005fWN4
Note: Creating a video ad like this requires microphones.

- Always ad #2: A follow-up to the #likeagirl campaign. www.youtube.com/watch?v=wtk3JTHfWm8

For tips on effective logo designs, see:

www.smashingmagazine.com/2009/08/vital-tips-for-effective-logo-design/
www.printwand.com/blog/5-facets-of-good-logo-design
www.logogarden.com/logo-design-tips.php

For examples of successful logo redesigns, go to:

www.1stwebdesigner.com/successful-logo-redesigns-improvements/

For both successful and unsuccessful logo redesigns, go to:

www.companyfolders.com/blog/best-worst-logo-redesigns-ever

Suggested Activities *continued*

Visual Arts Activities

Maggie Chang, Fiorello H. LaGuardia High School of Music & Art and Performing Arts

R4



R5



R6



R8



R10



Activity 2: Electronic Wearable Art—Becoming Robot

Resources

- Resource 3: The Three Laws of Robotics
- Resource 4: Women Programmers of ENIAC
- Resource 5: The Transistor
- Resource 6: Walter Cronkite and UNIVAC
- Resource 8: The IBM Pavilion at the World's Fair
- Resource 10: Watson on Jeopardy!
- A Computer in Your Pocket: An Infographic (Appendix)

Procedure

The goal of this activity is to create a piece of wearable art that explores the relationship between technology and the body, and the use of machines to enhance human ability rather than to do harm.

Ask students to analyze, through writing or discussion, these images of machines in chronological order: Resources 4, 5, 6, 8, and 10 (titles listed above), with the infographic entitled A

Computer in Your Pocket. Ask them to consider how *scale* has changed over time and thus the machine's *relationship to the body*. Compare these with examples of modern machines and devices.

Students can discuss (as a class or in small groups) modern society's connections with and dependence on its machines, both physical and emotional:

- * Describe a time you felt a machine was an extension of your body.
- * Describe a time you have ever felt love, fear, hate, and/or anger toward a machine or technology, as if it were alive. (*Poll the class to see which feelings predominate.*)

Then, discuss machines' positive and negative contributions, and answer these questions:

- * Over time, how has technology proven to be pos-

itive, enhancing human ability and experience? (*Examples of possible responses are: connects friends and family regardless of distance, connects those in need to those who can help, uncovers silent voices, educates, mobilizes people around a common concern to create positive change.*)

- * What are ways technology has been used to do harm or has helped facilitate harm? (*Examples of possible responses are: weapons, cyber-bullying, distractions from real issues, loss of in-person experiences, mobilizes people around a common concern to do harm.*)

Challenge students to use electronic parts to create a piece of wearable art that *must* follow Asimov's Three Laws of Robotics (Resource 3). Students can brainstorm the function and form of their electronic wearable art in relation to the laws by answering the following questions:

Suggested Activities *continued*

Visual Arts Activities

Maggie Chang, Fiorello H. LaGuardia High School of Music & Art and Performing Arts

About Law 1:

- * What are different ways humans can be harmed? (*This should include people harming each other and self-harm—physically, emotionally, or mentally.*)
- * From what harm would you like your wearable robotic sculpture to protect *you*?
- * To what part(s) of the body might this be connected? (*Abstract concepts can be encouraged, like protecting the heart from low self-esteem.*)

About Law 2:

- * Consider the task(s) you would like your wearable robotic sculpture to complete. Does this serve you or enhance your abilities while still following Law 1?
- * How is where you wear it on your body related to what it does?
- * How does its function affect its shape, texture, color, form, and other art elements?

About Law 3:

- * When constructing your wearable robotic sculpture, how will you ensure that it is sturdy and can be put on and taken off securely?
- * How will you ensure it securely fits your body, and is comfortable to wear, so it does not conflict with Law 1?

In order to create their pieces, ask students to collect and bring in machines, electronics, and technology parts that can be donated to the class for this project. Students can remind themselves how these materials were once used and should spend some time taking the materials apart, discovering their qualities, and what they can and cannot do. Teachers should provide additional materials to aid sculptures in their structural integrity and wearability. (*Suggestions for additional materials available at hardware and art stores: wire, adhesives, rubber, foam drawer liner, Velcro, nuts and bolts, snap buttons, and grom-*

nets. Students may also bring in unwanted accessories that can be taken apart and used.)

Students conclude by writing labels for their pieces and sharing in an exhibition of their work.

Discussion Questions

Some of these questions encourage students to think broadly about the resources used in this activity. Others are focused on bigger questions about human nature and existence.

Consider the following excerpt from “Robbie,” the first short story in Asimov’s *I, Robot*. It concerns a young girl, Gloria, her love for her robot, and her mother’s fear and disapproval of the relationship. In this excerpt, Gloria’s father, who is on her side, is suggesting an argument that he thinks will appeal to his wife. He also thinks, but doesn’t say, that it will reunite Gloria with her robot.

“All right. Here’s what I’ve been thinking. The whole trouble

with Gloria is that she thinks of Robbie as a person and not as a machine. Naturally, she can’t forget him. Now if we managed to convince her that Robbie was nothing more than a mess of steel and copper in the form of sheets and wires with electricity its juice of life, how long would her longings last?”

- * What qualities might make a machine appear to be human or animal-like? What qualities seem purely machine-like? When might the distinction blur? What does it mean to be “alive”?
- * Is there a danger if humans make robots and computer graphics imagery too human or too real? Why?

Consider Dr. Susan Calvin’s line from Asimov’s *I, Robot*, found in **Resource 3: The Three Laws of Robotics**: “*Mankind is no longer alone.*”

- * What do you think she meant? Do you agree? Why or why not?
- * Why might there be connections between technology and loneliness?

Suggested Activities *continued*

Visual Arts Activities

Maggie Chang, Fiorello H. LaGuardia High School of Music & Art and Performing Arts

Philosophers and physicists have suggested that *we* might actually be robots, living in a computer simulation.

- * Could our reality be a virtual reality?
- * How would you know? Why does it matter?

Research Project: How Has Technology Changed Art?

Technology has changed us as humans *and* as artists. Ask students to research artists from the last five decades who have been investigating and incorporating technology into their work:

- * Who is doing pioneering work using technology as their primary artistic medium?
- * What does this look like?
- * Which of the artists make technology their primary subject?
- * What questions does their work raise?

Based on their findings, ask students to write an essay or present a slideshow that describes the varying artistic perspectives on the subject of technology and art. Compare and contrast these works with traditional fine art.

- * How has technology changed art?
- * What does art effected by technology look (and sound) like?

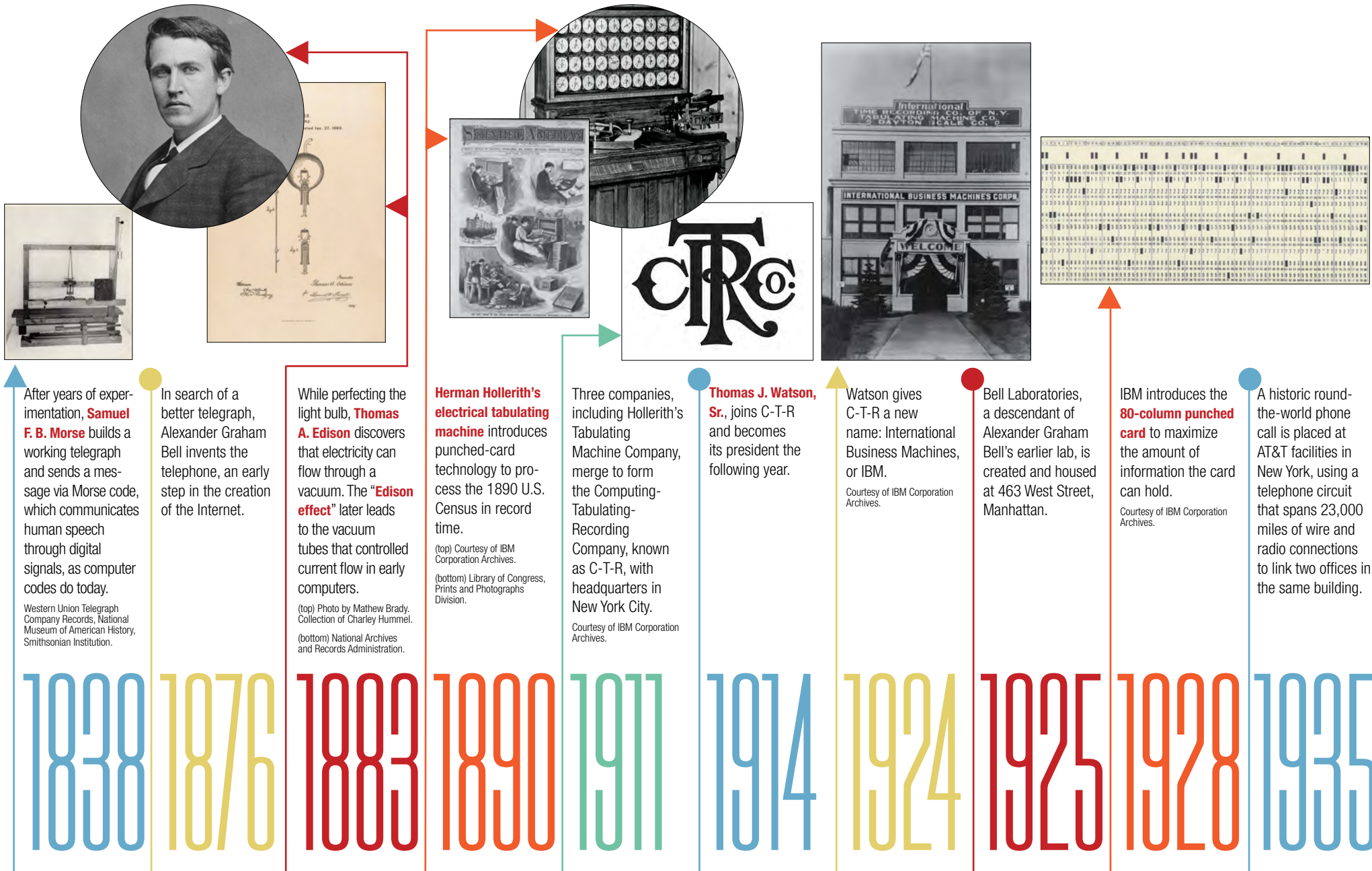
Suggested artists to

research: Lillian Schwartz, Max Mathews, Nam June Paik, Philippe Parreno, Yuri Suzuki, Chris Milk, Susan Philipsz, Haroon Mirza, Sayaka Ganz, Sheila Pinkel, Jason Lund, Marco Brambilla, Jon Kessler, and Simon Denny.

Silicon City: A Timeline

The following timeline illustrates New York's role in the development of computer technology. It functions as the centerpiece of the curriculum. All resources, life stories, and an image of the poster, Silicon City Now, can be reached by clicking on the links in the timeline.

Silicon City: A Timeline



Silicon City: A Timeline *continued*



Bell Labs mathematician George Stibitz conceives a computer that processes data using electrically operated switches. His 1937 Model K Adder tests the concept. It pioneers digital computing by using **binary numbers** (just 1s and 0s) to match the on/off switches of his relays.

Isaac Asimov publishes the first of his robot stories, introducing the fictional **Three Laws of Robotics** to establish human control over technology.

A Harvard team, including ★ **Grace Hopper**, programs the IBM-created Automatic Sequence Controlled Calculator, nicknamed the Mark I, to do calculations for the atomic bomb and other defense work.

Library of Congress, Prints and Photographs Division.

Continuing work begun during the war, ★ **women become the first programmers** of the massive ENIAC computer, nicknamed the Giant Brain, at the University of Pennsylvania.

Courtesy of the U.S. Army.

A Bell Labs team invents the **transistor**, for which the three scientists win the Nobel Prize for Physics. With the invention of the integrated chip in 1957, millions of transistors and all their circuitry can be etched in a single chip of silicon. The new technology will replace vacuum tubes and lead to **the miniaturization of computers**.

Courtesy of Alcatel-Lucent/ Bell Labs.

IBM completes its first large-scale digital calculator, the Selective Sequence Electronic Calculator (SSEC), which can modify a stored program.

Courtesy of IBM Corporation Archives.

On presidential election night, CBS uses the new **UNIVAC** computer to predict the outcome, but does not broadcast the computer's (correct) forecast of an Eisenhower landslide.

New-York Historical Society.

AT&T completes the laying of the first **transatlantic telephone cable** and holds a long-distance call connecting New York, Ottawa, and London.

CBS again uses the UNIVAC on election night, as it did in 1952, but this time trusts and broadcasts the computer's predictions. At IBM, **Tom Watson, Jr.** becomes chief executive officer and introduces a bold new **branding campaign**.

1937

1940

1944

1946

1947

1948

1952

1956

1956

Silicon City: A Timeline *continued*



IBM introduces FORTRAN (**FOR**mula **TRAN**slating System), a programming language designed for scientists and engineers to use in performing complex computations using English-like statements.

1957

At Brookhaven Laboratories on Long Island, William Higinbotham creates what may be the first video game, later known as Tennis for Two.

1958

COBOL (**CO**mmon **B**usiness **O**riented **L**anguage), a computer language for businesses, is created by a team that includes UNIVAC computer pioneer 🌟 **Grace Hopper**. It uses English-like syntax, easily understood and readable by programmers and users.

Courtesy of the Computer History Museum.

1959

In early April, IBM announces the System/360, a general-purpose family of computers that can be programmed for any task and expanded as needed. Later in the month, the **World's Fair opens in Queens**, introducing visitors to the newest technology and gadgets.

Courtesy of IBM Corporation Archives.

1964

Ed Catmull leads the newly formed New York Institute of Technology's Computer Graphics Laboratory, which will pioneer **computer-generated imagery (CG) techniques**.

1974



IBM introduces the personal computer, also known as the PC or the 5150. Ads feature an actor playing Charlie Chaplin's Little Tramp, to persuade people that the computer is easy to use.

Courtesy of IBM Corporation Archives.

1981

As California's Silicon Valley gains prominence, New York's leadership in advertising and business fuels Internet ventures such as the online ad network DoubleClick, and Prodigy, a text and graphics service offering news, shopping, games, and other features.

1990

With the founding of Meetup, and later Etsy, Huffington Post, BuzzFeed, Kickstarter, Tumblr, and Vimeo, New York regains the spotlight as a booming capital of our digital future.

2002



The IBM computer named Watson in honor of Thomas J. Watson, Sr., appears on TV's *Jeopardy!* and defeats all-time winners Brad Rutter and Ken Jennings.

Seth Wenig/Associated Press.

2011

July 9, 2015: IBM announces a working version of a computer chip only seven nanometers wide (equal to a few strands of DNA), promising computers with far more speed and power. For a glimpse of New Yorkers working in technology today, see **Silicon City Now**.

2015

Resources

Resource 1: Hollerith's Electrical Tabulating Machine 40

Resource 2: Punched Cards 41

Resource 3: The Three Laws of Robotics..... 42

Resource 4: Women Programmers of ENIAC 43

Resource 5: The Transistor 44

Resource 6: Walter Cronkite and UNIVAC 45

Resource 7: The First Transatlantic Telephone Cable 46

Resource 8: The IBM Pavilion at the World's Fair 47

Resource 9: Design and Branding..... 48

Resource 10: Watson on *Jeopardy!*..... 49

Resource 11: *A Brief History of Computer Graphics: Made in New York* 50

Resource 1: Hollerith's Electrical Tabulating Machine

Herman Hollerith's tabulating invention had just started processing the 1890 census when this *Scientific American* appeared. The magazine's readers had probably heard of it, but this illustration showed them how it worked.

In the first step (bottom image), workers unpacked the crates of handwritten forms, called schedules, that had been mailed in by census supervisors (see the life story of **Herman Hollerith**). The schedules were then delivered to clerks, often ★ women, who sat at counting machines (center image). They used a numbers-only keypad to enter the tallies that enumerators were required to put at the top of each schedule: the number of families in the dwelling, the number of people in the dwelling, and the number of people in the family. The round dials on the counting machine kept track of the totals.

Next stop: the card-punching station (upper right). The clerk is using a device to punch holes in a blank card that measured $6 \frac{5}{8} \times 3 \frac{1}{4}$ inches—about the same size as a dollar bill at the time, because Hollerith stored the cards in boxes he bought from the Treasury Department. A hole in one position meant “male.” In another, it meant “married,” etc. A card was made for every person in the census—63 million people—but names were not recorded. Each card's corner was clipped, so if it was dropped, it was obvious which way was right-side up.

The punched cards were then sent to the tabulator (upper left), the time-saving heart of Hollerith's invention. It resembled the counting machine (center image), but it did a different task. In the illustration, the clerk has placed one punched card in the bottom portion of the card-reader. When he pulls the lever, he lowers the top portion, which contains a grid of retractable metal pins. If a pin lines up with a hole in the card—meaning “male,” or “married,” for example—it

falls through and lands in a small pool of mercury. This completes an electric circuit that causes the appropriate dials for “male” or “married” to advance. The machine simultaneously reads and counts all the punched holes in a card.

Clerks worked in shifts around the clock in a new Census Building (center left) in Washington, D.C. Hollerith had paid for electrical service to be brought to the building's basement. He used it to recharge the batteries that actually ran the machines.

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Scientific American, cover, August 30, 1890. Library of Congress, Prints and Photographs Division, LC-USZ62-58724.

Guiding Questions

What is the magazine's message about this technology? How can you tell?

Who has the most skilled jobs? The least skilled?

★ **What do you notice about the roles of men and women?**

Resource 3: The Three Laws of Robotics

The idea of a mechanical, almost-human creature is not new, but no one spoke of “robots” until the 1920s. The word belonged to the new genre of science fiction, in which writers and readers imagined what the world might be like far in the future, when technology would dom-

inate. Readers tended to be young men with some scientific or technical expertise.

Isaac Asimov (1920–1992) was born in Russia but raised in New York. In 1950, nine of his science fiction short stories were collected in a book called *I, Robot*. By then, Asimov had earned a Ph.D. in chemistry, but he soon turned to writing full time. He wrote

real science, and he wrote science fiction.

I, Robot, set in the year 2058, was narrated by a woman scientist named Dr. Susan Calvin. That alone set it apart. But it also introduced what Asimov called the Three Laws of Robotics—he coined the word “robotics.” He was trying to change the existing, unwritten rules that seemed to govern robots in science fiction: they became uncontrollable and killed their human creators. Asimov’s “laws” made robots safer to be around, and stories about them more interesting. But they did not put an end to human fears about technology.

In the introduction to *I, Robot*, Asimov gave Dr. Susan Calvin these lines:

There was a time when humanity faced the universe alone and without a friend. Now he has creatures to help him; stronger creatures than himself, more faithful, more useful, and absolutely devoted to him. Mankind is no longer alone.

Dr. Calvin may be speaking for Asimov himself. In an essay in *Robot Visions*, a 1990 book that appeared shortly before he died, Asimov wrote:

Computers, . . . if they get intelligent enough to “take over,” may also be intelligent enough no longer to require the Three Laws. They may, of their own benevolence, take care of us and guard us from harm.

Isaac Asimov, writer and man of science, saw nothing to fear in the new technology.

Guiding Questions

How far into the future did Asimov set his *I, Robot* stories? Why do you think he chose that time span?

According to these “laws,” could a robot be ordered to kill an enemy? Could it kill in self-defense?

What words in the final two quotations signal how Asimov felt about technology? What role did he see for robots?

Some laws, like the law of gravity, describe how the physical world works. Others, like laws against murder or theft, are meant to control behavior. How do you think Asimov was using the word “laws”?

The Three Laws of Robotics

1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Handbook of Robotics, 56th Edition, 2058 A.D.

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“Three Laws of Robotics” from *I, ROBOT* by Isaac Asimov, copyright © 1950 by Isaac Asimov. Used by permission of Bantam Books, an imprint of Random House, a division of Penguin Random House LLC. All rights reserved.

Resource 4: ★ Women Programmers of ENIAC

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 (**E**lectronic **N**umerical **I**ntegrator and **C**omputer). 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.

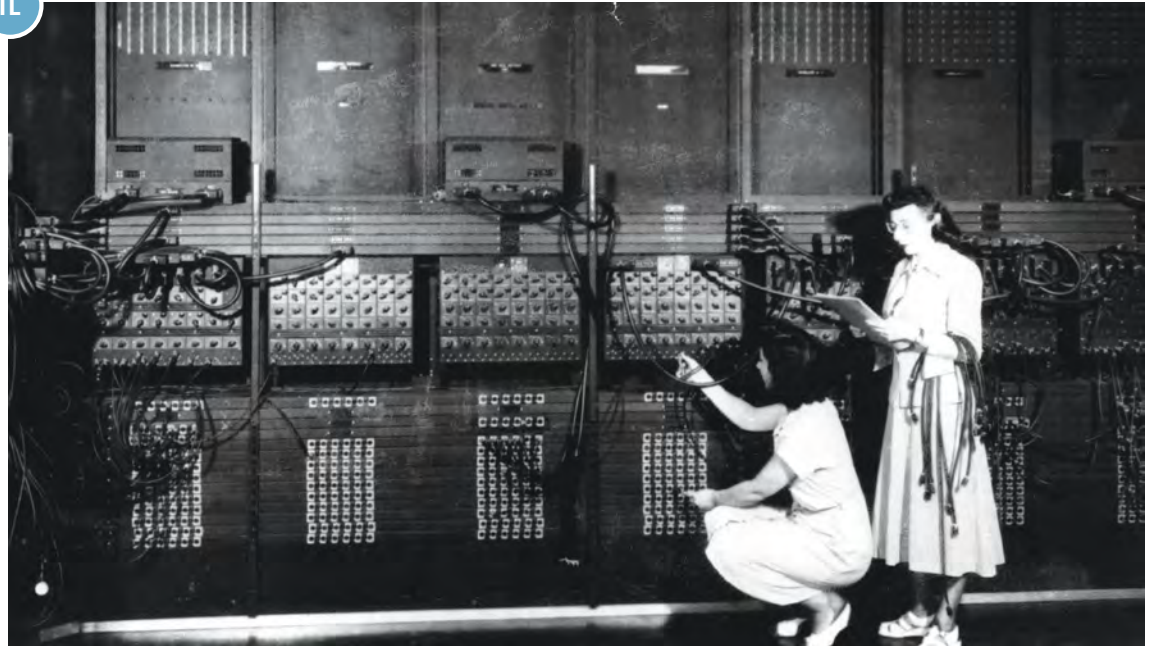
Work on it continued, however. This photo, taken around 1946, shows only a portion of the room-sized computer. It was completely electronic, so it should have been far faster than the other big war-time calculator, the Mark I, developed by IBM and programmed at Harvard by Grace Hopper and others. The 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 Marlyn 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

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Marlyn Wescoff Meltzer (1922–2008) and Ruth Lichterman Teitelbaum (1924–1986) Wiring the Right Side of ENIAC, ca. 1946. Reproduction Courtesy of the U.S. Army.

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.

Guiding Questions

How does the composition signal what the photographer wanted viewers to notice? What message does the photo send?

What can you tell about the women? Would your answers change if they were facing the camera and smiling?

What can you tell about the machine? Can you see any patterns in how the cables are attached? What might the patterns mean?

Resource 5: The Transistor

Almost as soon as vacuum tubes allowed for the development of computers and other electronics, researchers began looking for a way to replace them. They were essential as amplifiers and on/off switches, but far from perfect. Thousands of them were needed in a single computer (see [Resource 4: Women Programmers of ENIAC](#)), and since each one was roughly the size of a light bulb, they made the early machines enormous. They also burned hot and lasted only a couple of days. Repairs and replacements were constant.

AT&T used vacuum tubes in its telephone technology, and by the mid-1940s, it was clear that future phone service would require something much better. So Bell Labs, AT&T's research facility, began to experiment with semiconductors, solid materials that can both conduct electricity and insulate against it. William Shockley managed one of the research teams at Bell Labs.

He had done semiconductor research, and thought it was promising. He assigned electrical engineer John Bardeen and physicist Walter Brattain to the task: Find a way to use a semiconductor to control an electric current.

In late 1947, after many unsuccessful attempts, Bardeen and Brattain created a small, unassuming device that combined a tiny piece of a semiconductor called germanium, a thin strip of gold, a few wires, and batteries. It produced a slight but encouraging gain in power. After they tinkered with it, they called some colleagues together and fed a voice signal into the device. The voice got significantly louder. The device had amplified the sound. They had done it!

After a name-the-device vote at Bell Labs, it was called a transistor. It could do what vacuum tubes do: amplify a current, and act as an on/off switch. But it was many times smaller than the tubes. A Bell Labs' announcement said that more than a

hundred transistors could be held in an outstretched hand. The transistor also ran cooler than a vacuum tube, used far less energy, and was much less prone to failure.

A decade later, separate teams of scientists discovered that millions of transistors, along with all their circuitry, could be printed in layers on a single chip of silicon. The transistor and this "integrated chip" (or "integrated circuit") set off a revolution and led to the miniaturization of computers. Room-size machines filled with vacuum tubes were soon a thing of the past. In time, computers would become relatively inexpensive, and small enough to rest on your lap,

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(Left to right) John Bardeen, William Shockley, and Walter Brattain, June 1948. Courtesy of Alcatel-Lucent/Bell Labs.

hold in your hand, or wear on your wrist. (See [A Computer in Your Pocket: An Infographic](#).)

John Bardeen, Walter Brattain, and William Shockley were awarded the 1956 Nobel Prize in Physics for the development of the transistor.

Guiding Questions

What does this photo tell you about the nature of the research on the transistor? What tools and materials can you identify?

Why was the transistor/integrated chip technology so revolutionary?

How has the transistor/integrated chip affected the technology you use today?

Resource 6: Walter Cronkite and UNIVAC

Election night, 1952. Dwight D. Eisenhower, who led the Allied forces during World War II, was running for president against Adlai Stevenson, governor of Illinois. From the CBS studios in New York City, Walter Cronkite led the network's election coverage. His voice was familiar to people who had listened to his radio reports during World War II, but this was the first time he anchored television coverage of a presidential election. It was also the first election in which television played a major role, and the first time a computer, UNIVAC (**UNIV**ersal **A**utomatic **C**omputer), was used to predict the outcome.

In this photo, taken at the UNIVAC headquarters in Philadelphia, console operator Harold Sweeney is seated at the controls. Cronkite (right) is standing with J. Presper Eckert (center), who co-designed UNIVAC with John Mauchly. (As principals of Eckert-Mauchly Computer

Corporation, they had designed ENIAC [Resource 4] a few years earlier, before their company was purchased by Remington Rand.) UNIVAC introduced the use of magnetic tape, stored on reels, for data storage. Grace Hopper was the UNIVAC's senior mathematician. In the days before the presidential election, her team loaded UNIVAC with information from previous elections, so it could compare the early voting results to real data. ★

CBS executives saw the computer as a flashy way to draw viewers, but Cronkite was skeptical: "Actually we're not depending too much on this machine. It may turn out to be just a sideshow." On election night, reporter Charles Collingwood sat at a mock-up of the console at the New York broadcasting studio—the actual UNIVAC was far too large to be moved, and did its predicting from Philadelphia. Collingwood had been advised by CBS executives to humanize the machine, so he made jokes and addressed it personally. He told the audience that using the machine was an experiment. "We hope it works," he added.

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J. Presper Eckert Explains UNIVAC to Walter Cronkite, ca. 1952. Courtesy of the Computer History Museum, #102621829, Lot #7413.2015.

It did, extremely well. With only 5 percent of the votes in, UNIVAC predicted 100-1 odds in favor of an Eisenhower landslide. The number seemed outrageous because opinion polls predicted a close race. Someone on the UNIVAC team, or at CBS, decided not to share the prediction with the audience, but Eisenhower did win in a landslide. When he ran for reelection four years later, again facing Stevenson, he

won again. And CBS used UNIVAC again, but this time the machine's predictions were trusted.

UNIVAC had been used in the 1950 U.S. Census, but its appearance on election night gave many viewers their first glimpse of a computer at work. People began to call every computer a UNIVAC, and more orders were placed for the giant technology than Remington Rand could fill.

Guiding Questions

What early attitudes about computers are evident in this story? What attitudes do you see in the three men in the photo?

Based on the photo, how did the UNIVAC communicate its results?

Why did CBS think it was important to humanize UNIVAC?

Resource 7: The First Transatlantic Telephone Cable

Beginning in the 1920s, a New Yorker could call London by radiotelephone. This AT&T service was a breakthrough—callers could clearly hear a voice from the other side of the Atlantic—but in bad weather, the signal could sound, as one writer put it, like “cosmic frying pans.” AT&T and its research arm, Bell Laboratories (**Resource 5: The Transistor**), spent three decades researching a way to bring better service to many more people. Ultimately, the plan called for two undersea copper cables, each about 1½ inches thick, for the deep-water expanse, and a single cable for the shallower waters closer to shore. The twin cables would work like a two-lane road, each cable handling calls in one direction only. Designed and installed by AT&T and Bell Labs, working with partners in Canada and the United Kingdom, it was called the Transatlantic Telephone Cable System 1, or TAT-1.

Beginning in 1955 and continuing the following summer, the cables were

laid by the British steamship *Monarch*. Unused cable was stored in sections in the ship’s hold. Crewmen spliced sections together aboard ship, and fed the cable into the ocean as the ship moved slowly. At regular intervals, devices called repeaters were added to the cable to amplify the electrical signal, which would otherwise weaken as it traveled. These repeaters were the critical development that allowed the project to go forward. Transistors had been invented by Bell Labs a few years earlier, but they were considered too new and risky for this monumental task. So the designers relied on familiar technology for the repeaters: vacuum tubes, redesigned to fit flexibly within the cable and withstand deep-sea conditions.

The photo shows the last stage of the project, as crewmen pulled the second cable ashore in Clarenville, Newfoundland. The cable’s other end was 2,000 miles away, in the Scottish village of Oban. In between, it lay on the sea floor, as much as two miles below the surface, connecting North America to Great Britain.

TAT-1 was an engineering milestone that marked the beginning of the modern era of cable communications. Three years later, TAT-2 connected New York to France. In 1962, AT&T launched Telstar, the world’s first communications satellite, which could receive a signal, amplify it billions of times, and retransmit it to earth. Today our global system relies on a network of satellite and radio technology, as well as undersea cables. Many of today’s cables, including the currently operating TAT-14, are fiber-optic. They have brought speed-of-light transmission, measured in thousandths of a second, but they are subject to a new threat. Sharks are known to sink their teeth into fiber-optic cable, interrupting service and requiring expensive repairs. There were no reported shark attacks on TAT-1’s copper cables.

For an interactive map showing the cable lines in use or planned in 2015, go to: www.telegeography.com/telecom-maps/submarine-cable-map.1.html

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AT&T, Transatlantic Telephone Cable (TAT-1) Pulled Ashore at Clarenville, Newfoundland, ca. 1955. Reproduction Courtesy of the AT&T Archives and History Center.

Guiding Questions

What does the number of men suggest? Is there any evidence that the photo only shows part of the crew?

Who might be in charge?

The men are holding a rope—where’s the cable?

What does the line of barrels suggest?

How does AT&T’s trust of cable technology compare to programmers’ uncertainty about UNIVAC’s 1952 election predictions (**Resource 6: Walter Cronkite and UNIVAC**)? What might explain any differences?

Resource 8: The IBM Pavilion at the World's Fair

On April 22, 1964, the New York World's Fair opened in Flushing Meadows, Queens. Six months later it closed for the winter, and reopened the following summer. In those two seasons, over 50 million people visited.

The Fair focused especially on American industry. Companies like IBM and AT&T built pavilions to showcase their newest, most exciting products. The AT&T pavilion presented the Picturephone, which allowed people to see the person they were speaking with, and a model of Telstar 1, "the first satellite capable of cross-ocean relay of telephone calls, TV and data messages." New technology was a mainstay of world's fairs. The 1939 Fair, held on the same spot, had introduced the public to television and air conditioning. Not all of the new gadgets were a success, though. The Picturephone, for example, never caught on and was withdrawn from the market after a few years.



New York World's Fair IBM Pavilion, 1964. Courtesy of IBM Corporation Archives.

The IBM pavilion was designed by the Office of Charles and Ray Eames and Eero Saarinen Architects. They were part of the distinguished design team Eliot Noyes assembled for IBM (**Resource 9: Design and Branding**). Viewed from the

outside, the centerpiece of the pavilion was "the Egg," a huge rounded structure with "IBM IBM IBM" repeating in circular rows and visible from a good distance away. "The Egg" was a tribute to the signature round typography ball in the

Guiding Questions

What do you notice about the people waiting in line? Think about age, gender, race, clothing. How would you characterize them?

Why would IBM use the Selectric typewriter ball as the model for the dome? To whom would it appeal?

What similarities are there between the Picturephone and current technology? What differences do you see?

Unidentified Artist, Opening Ceremonies of Picturephone with Mrs. Lyndon B. Johnson (1912–2007) in Washington Chatting Via See-As-You-Talk Telephone with Robert F. Wagner (1910–1991), Mayor of New York City, and Dr. Elizabeth A. Wood (1912–2006), the First Woman Scientist at Bell Labs, June 24 1964. Courtesy of Alcatel-Lucent/Bell Labs.

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IBM Selectric, 1961. Courtesy of IBM Corporation Archives.

Selectric typewriter, which was dramatically changing the American office.

Visitors waited in long lines, for an hour or more, to enter a grandstand called the People Wall, which lifted 500 people at a time 53 feet into "the Egg." Once inside, they watched a multiscreen show called *Think*, which explained how computers work in ways intended to make the new machines seem less alien, more "like us."

After the show, visitors explored the rest of the pavilion. They stopped at the Typewriter Bar to try the Selectric for themselves. They watched puppets explain data processing and explored computer applications. At the "probability machine," they saw demonstrations of how science used probability to detect order in random events.

For decades before the 1960s, scientists and engineers had been building computers and improving every aspect of their function. American companies were beginning to invest millions to purchase them. But for ordinary people, the 1964 World's Fair was their first chance to explore the computer technology of the future.



Resource 9: Design and Branding

Thomas J. Watson, Sr., when he was in charge of IBM, knew that customers judge a company by the people in its sales force as well as by the products they sell. He insisted that IBM salesmen—they were always men in the early years—wear appropriate business clothing, which often meant a dark blue suit, white shirt, low-key tie, and a brown felt hat. When an IBM salesman came to call, the clothes communicated important messages about the man himself and the company he represented.

Under his son's leadership, design became a much greater part of IBM culture. (See the life story of **Thomas J. Watson, Sr. and Thomas J. Watson, Jr.**) In the early 1950s, Tom Watson (the informal name he preferred) found the corporation's look tired and old-fashioned. When he took over IBM in 1956, he hired architect and industrial designer Eliot Noyes as a consultant. Watson later



(top) Paul Rand (1914–1996), Eye Bee M, 1981. Courtesy of IBM Corporation Archives.
(bottom) Paul Rand (1914–1996), IBM 8 Bar Logo, 1972. Courtesy of IBM Corporation Archives.

remembered an early conversation with Noyes:

I wanted the factories, products, and sales offices all done in such a way that a person could look at any of them and say instantly, "That's IBM!" But Noyes said this would be self-defeating. If we tried to fix a single, uniform corporate image, it would eventually become tired and dated. Instead,

he suggested that IBM's theme be simply the best in modern design.

Noyes recruited graphic designer Paul Rand and Charles and Ray Eames, the husband-and-wife designers and filmmakers. This core team changed IBM inside and out, and produced some of the most iconic designs of the twentieth century.

TL

Noyes himself designed the Selectric typewriter, a machine so popular with consumers that it dominated the American workplace (**Resource 8: The IBM Pavilion at the World's Fair**). Rand created the striped IBM logo, introduced in 1972 and still in use today, to immediately signal the company name and to communicate speed and dynamism. Rand also designed the playful and popular eye-bee-m version, which was never used as IBM's logo. Charles and Ray Eames created the multi-screen film *Think*, dazzling visitors to the IBM pavilion at the 1964 World's Fair.

IBM's focus on design affected the way the public viewed the company. It also changed the way corporations build their reputations and promote themselves in the public eye. It was a lesson taken very much to heart by other companies, especially a plucky California startup called Apple.

Guiding Questions

What corporate values do you think the required business suit conveyed to IBM customers? What companies today have dress codes for workers? What do those clothes communicate?

What do speed and dynamism, the concepts behind Rand's striped IBM logo, suggest about perceptions of IBM in the early 1970s?

Why do you think the striped IBM design became the company's logo, while the eye-bee-m version did not?

In what ways was the rebranding of IBM consistent with its values? How do you think this contributed to the strong identity and success of the company?

Resource 10: 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.

The *Jeopardy!* story was told in a Nova program called "Smartest Machine on Earth," which aired on PBS and can be seen at www.pbs.org/wgbh/nova/tech/smarter-machine-on-earth.html.

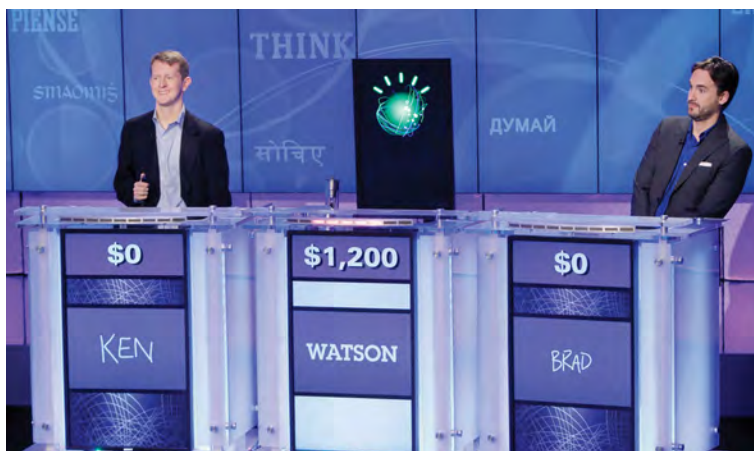
TL

Guiding Questions

Why do you think the avatar was designed to look as it does? What words would you use to describe it? How does it relate to the appearance of the other contestants?

Why do you think Jennings wrote his "computer overlords" message? Why would he use that phrase? What attitudes about technology, and about humans, does it convey?

What was your reaction to Watson's victory? Why do you think you felt as you did?



Seth Wenig, Man vs. Machine, January 13, 2011. Associated Press, 11011318225.

Resource 11: *A Brief History of Computer Graphics: Made in New York*

The animated movie *Toy Story*, released in 1995, wowed audiences and critics alike with the story of Sheriff Woody, his rival, Buzz Lightyear, and a chorus of familiar toys that came to life when no humans were around. It earned several Academy Award nominations, set box office records, and made Pixar Animation Studios a creative and financial powerhouse.

Toy Story was also a pioneer in the collaboration of art and science, the first feature-length animation produced entirely with computer-generated imagery. Today, it is a standard tool in filmmaking, where it is called CG. It allows live-action characters to be chased by dinosaurs and befriended by lions, and all but replacing the legions of artists who once drew and colored every frame in animated films.

This five-minute film explores the New York origins of computer-generated imagery. It begins in the 1960s at Bell Labs, where teams of artists, scientists, and engineers experimented at the frontier of filmed sound and light. Then in the 1970s, computer scientist Ed Catmull was hired to run the computer graphics lab at the New York Institute of Technology, which became the epicenter of a revolution in filmmaking. Bell Labs and NYIT both drew on the abundant intellectual and artistic energies of New York. The breakthroughs pioneered here set in motion a process of digitization that has changed the way we experience media throughout the world.

In 1979, Catmull and several members of his team were recruited by George Lucas to develop CG capabilities for Lucasfilm. When Apple founder Steve Jobs purchased Lucasfilm's digital division in 1986, Pixar Animation Studios was born, cofounded by Jobs, Ed Catmull, and Alvy Ray Smith. Today, Ed Catmull is the head of Disney Animation Studios, which purchased Pixar in 2006.

TL

Guiding Questions

What role did Bell Labs play in laying the groundwork for computer-generated imagery?

What role did the New York Institute of Technology play?

What do you think motivated the scientists and artists who worked on CG in the 1960s and 1970s? What was their vision? What made it exciting?

The film can be found on the flash drive in the folder titled **Resource 11: *A Brief History of Computer Graphics: Made in New York.***

Life Stories

Samuel F. B. Morse	52
Thomas A. Edison	53
Herman Hollerith.....	54
Grace Hopper	55
Thomas J. Watson, Sr. and Thomas J. Watson, Jr.	57

Life Story: Samuel F. B. Morse (1791–1872)

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. (See the pre-visit Morse Code **activity**.)

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.

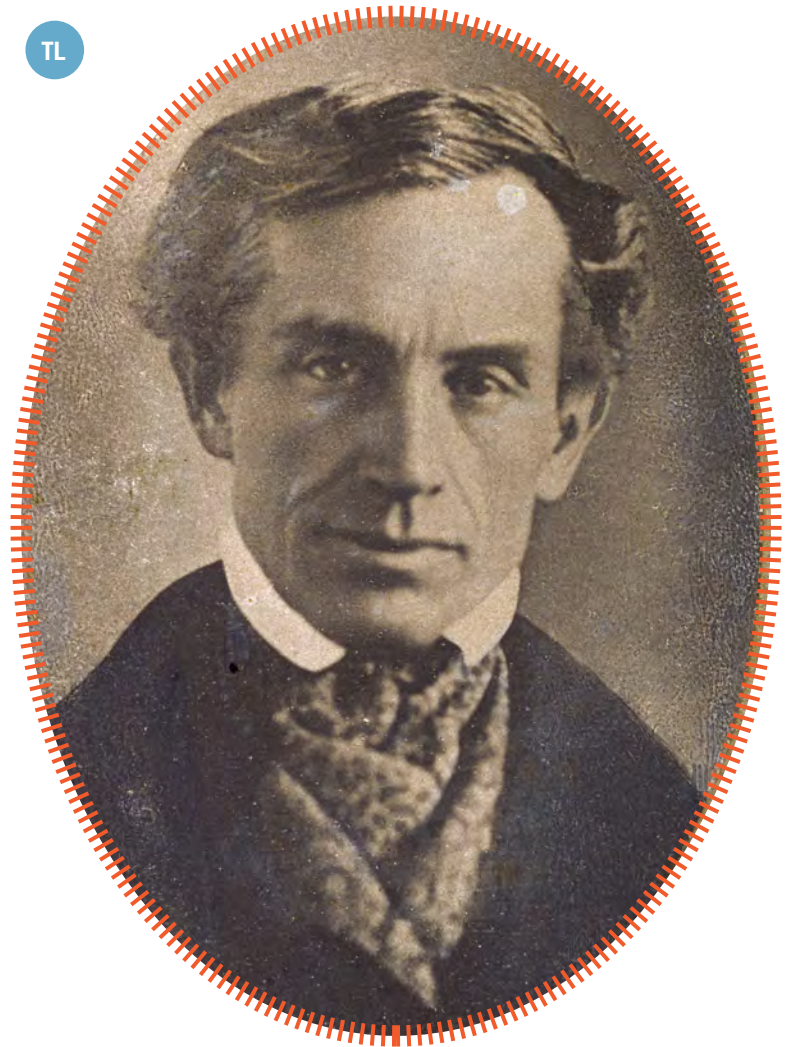
In England, William Fothergill Cooke and Charles Wheatstone designed their own workable telegraph, with its own language. But Morse code dominated and became the accepted international language of telegraphy. It was the ancestor of modern computer code, using dots and dashes the way computer software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

Guiding Questions

Which factors most helped Morse succeed?

How much time lapsed between the first discovery and the first working telegraph? Between the first message and the 12,000 miles of lines? What does this indicate about the process of invention, and the readiness to accept it?

Why do you think Morse chose “What hath God wrought,” as his first message? What do you think he meant?



Louis-Jacques-Mandé Daguerre (1787–1851), Portrait of Samuel F. B. Morse (1791–1872), 1840. Reproduction Archives of American Art, Smithsonian Institution.

Life Story: Thomas A. Edison (1847–1931)

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 (see the life story of **Samuel F. B. Morse**). 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.

Guiding Questions

How did Edison’s childhood prepare him for his work?

How did Edison’s scientific discovery influence the creation of computers?



Mathew B. Brady (1822–1896), Professor Thomas Edison (1847–1931) and His Speaking Phonograph, 1878. Collection of Charley Hummel.

Life Story: Herman Hollerith (1860–1929)

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.

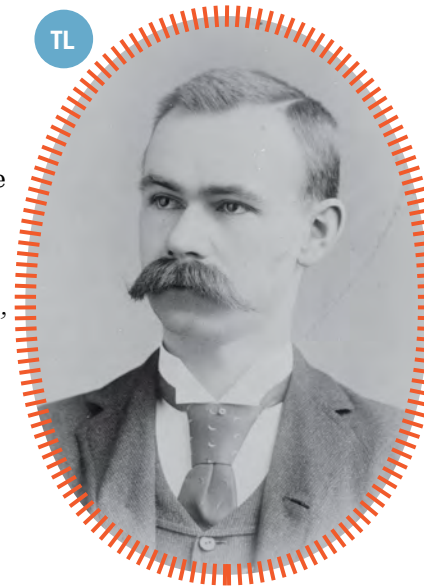
The Census Bureau's task was to draw statistics from the schedules. How many people lived in New York? How many factories used steam power? The only way to get this information was to hire armies of clerks to read the handwritten schedules one by one and tabulate, or organize, the data. This is where 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

TL



C. M. Bell (ca. 1849–1893), Portrait of Herman Hollerith (1860–1929), ca. 1888. Library of Congress, Prints and Photographs Division, C. M. Bell, photographer. LC-USZ62-115982.

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. (How did his design work? See **Resource 1: Hollerith's Electrical Tabulating Machine.**)

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.

Guiding Questions

What factors contributed to Hollerith's success?

How did Hollerith use old discoveries to create something new?

How much time lapsed between Hollerith's hiring at the Census Bureau and the use of his machine in the census? What does that time frame suggest?

Life Story: ★ Grace Hopper (1906–1992)

She 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

continued



Dr. Grace Hopper, Director, Systems Research, Remington Rand, ca. 1961. Library of Congress, Prints and Photographs Division, LC-USZ62-111439.

languages that allow human operators to tell computers what to do, and how. In 1957, IBM released FORTRAN (**FOR**mula **TRAN**slating), 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 (**CO**mmon **B**usiness **O**riented **L**anguage) 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. Howard Aiken commented, years after working with her, "Grace was a good man."

Guiding Questions

How did Hopper's decision to join the WAVES affect her future, and the history of computers?

How did her early years prepare her for the work she did during and after the war?

What do you think Howard Aiken meant when he said, "Grace was a good man"? Do you think he would say the same thing today? How would you describe Grace Hopper?

Life Story: Thomas J. Watson, Sr. (1874–1956) and Thomas J. Watson, Jr. (1914–1993)

Thomas J. Watson, Sr. (1874–1956)

Thomas J. Watson, Sr., was born on a farm in upstate New York, but he apparently did not want the farmer's life. After high school, he took a job as a bookkeeper, then worked in a hardware store. For a while, he was a traveling salesman, carting sewing machines and musical instruments to potential buyers in a wagon. Next, he opened a butcher shop, which failed. But things turned around for him when he was 22 and began working as a salesman for the National Cash Register Company (NCR). After he worked his way up to sales manager, he used mottos to motivate salesmen. The simplest was "Think."

By 1912, Watson was living in Dayton, Ohio, where he met and married Jeannette Kittredge. In 1914, shortly after the birth of their first child, Thomas, Jr., he left NCR and took a job with the Computing-Tabulating-Recording Company in New



One month before his death on June 19, 1956, IBM Chairman Thomas J. Watson, Sr. (right) hands over the reins of the company to his eldest son, Thomas J. Watson, Jr. (left), 1956. Courtesy of IBM Corporation Archives.

York City. The following year, he was made president, a job he would hold for more than forty years. C-T-R was a consolidation of four smaller firms, one of which was Herman Hollerith's Tabulating Machine Company. It sold time clocks and scales, in

addition to tabulating equipment. In 1925, Watson gave C-T-R a new, bolder name that reflected his ambitions: International Business Machines, or IBM.

IBM dominated the punched-card tabulation market when

this technology was by far the best way for companies to keep track of their business. Mr. Watson, as he was known even by close associates, was a commanding leader. He built a sales force that represented his personal values—sobriety, hard work,

discipline—and his goals for the company. Salesmen were required to wear accepted business clothes, which often meant blue suits, white shirts, conservative ties, and brown felt hats. They were expected to be loyal, think of themselves as winners, and never to drink on the job. At sales meetings, they sang spirited IBM songs, like "Ever Onward." They absorbed Watson's philosophy, conveyed in sayings mounted on placards around the office. Never Feel Satisfied. Study. Analyze Yourself. Think.

Under Watson's leadership, IBM became a household name immediately associated with technology and progress.

Thomas J. Watson, Jr. (1914–1993)

Mr. Watson's son was a less formal person than his father. He liked to be called Tom. But like his father during his early years, he was considered a nice young man without much promise. Academically, he

said later, he was a zero. But his father wanted him to join IBM, and after graduating from Brown University—his father had pulled strings to get him admitted—he did. And there, like his father, he discovered what he was good at. He became president when he was still in his 30s. When his father died in June, 1956, Tom Watson took the company's reins. For the next fifteen years, IBM grew far beyond what even his father had imagined.

The senior Watson had focused on building a small firm into a large one, training a top-level sales staff, and creating a strong corporate culture. His son inherited a thriving company, and could afford to pursue the new ideas that interested him, including the design of the company's products and showrooms, which he thought looked dull and old-fashioned. One of Tom Watson's first actions was to hire a design consultant: Eliot Noyes, an architect and former curator of industrial design at the Museum of Modern Art. He gave Noyes

an enormous task: to change the way IBM presented itself to the world. It wasn't a question of simply looking better. The goal was to show IBM as a leader, a powerhouse company at the forefront of design, technology, and ideas. IBM's products, packages, logo, marketing material, even the buildings, would reflect not only the best of modern design, but the values of the corporation. Today this kind of branding is common, but IBM and Noyes were the pioneers. (See [Resource 9: Design and Branding](#).)

Most significantly, Tom Watson, Jr., moved IBM into the world of electronic computers, which his father had resisted. In the 1960s, he bet the company's very existence by investing billions to develop a general-purpose computer that could be programmed for any task. Watson announced the System/360 in April 1964. A family of compatible computers, it allowed businesses to add new components as they grew, and to program the system

to address their changing needs. It was revolutionary. Though delivery would not begin until 1965, orders for the System/360 poured in, well beyond what IBM had forecast. Tom Watson's gamble more than paid off, and it led to a twenty-year period when IBM dominated the computer industry from its expansive new headquarters in Armonk, New York.

Guiding Questions

What different leadership strengths did the father and son possess?

How did each contribute to IBM's brand, to the way people viewed the corporation?

What impact did each man's vision have on the company, and the larger world?

Appendix

Writing Numbers in Binary: An Infographic 60

A Computer in Your Pocket: An Infographic..... 61

Predicting 2015—High School Essays from 196562

Silicon City Now64

Glossary.....65

Books and Websites66

Source Notes67

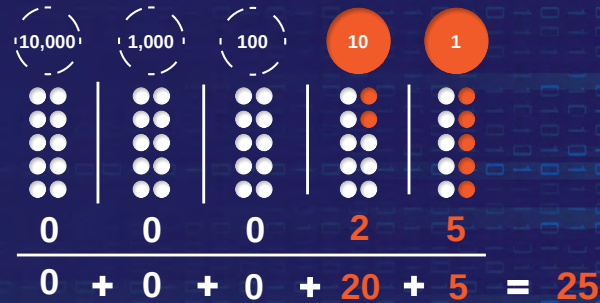
Standards.....69

Writing Numbers in Binary

In **Decimal**,
everything is based on **10**

We write numbers using columns that increase by 10 times (1s, 10s, 100s, 1,000s, etc). Each column can hold 10 digits (0-9).

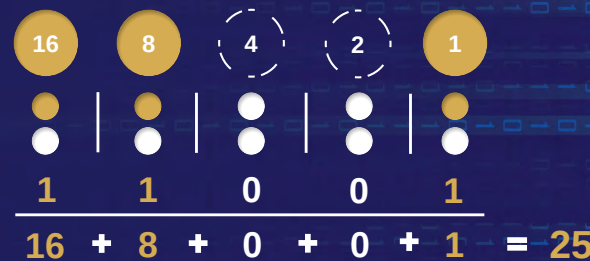
Twenty-Five in Decimal is **25**



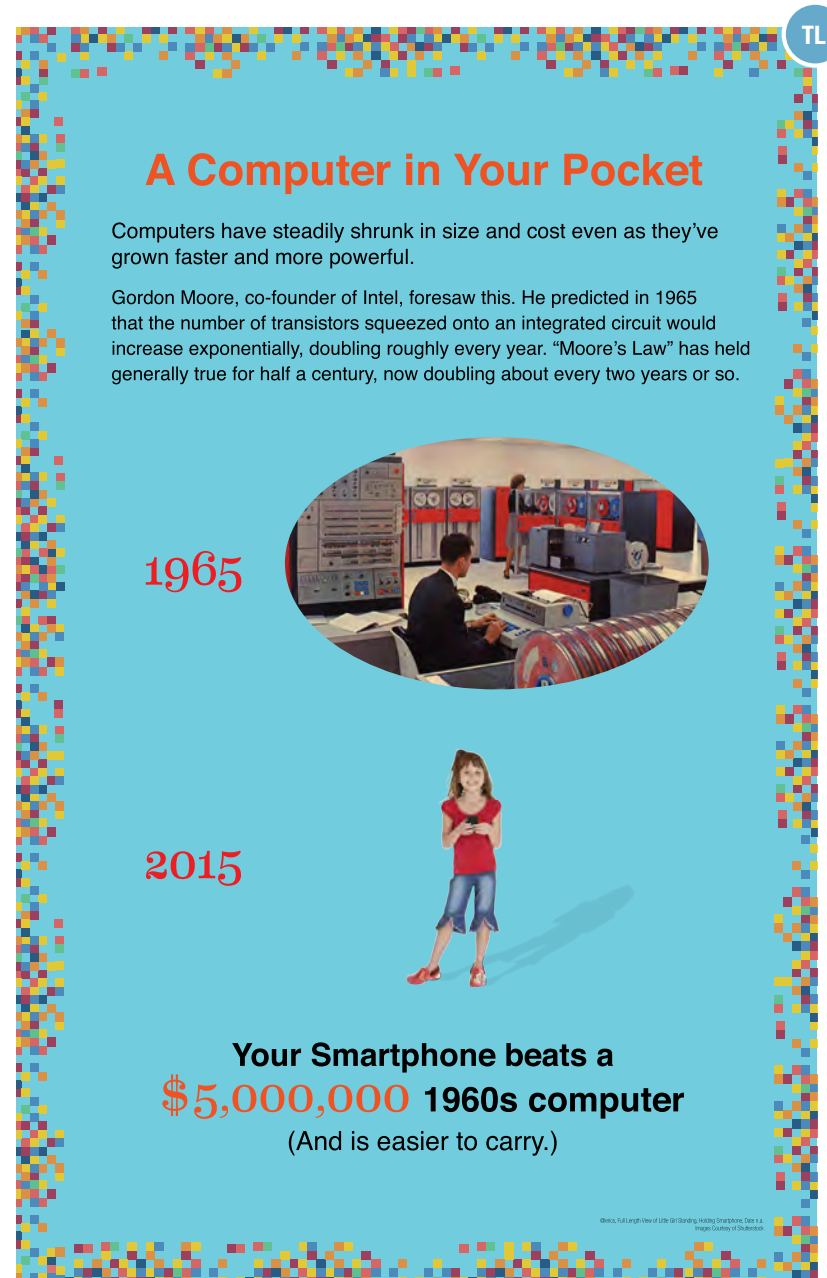
In **Binary**,
everything is based on **2**

We write numbers using columns that increase by 2 times (1s, 2s, 4s, 8s, 16s, etc). Each column can hold 2 digits (0 or 1).

Twenty-Five in Binary is **11001**



Appendix: A Computer in Your Pocket: An Infographic



Appendix: Predicting 2015—High School Essays from 1965

In 1965, the Empire State Building, in cooperation with the *World-Telegram*, a New York City newspaper now out of business, held an essay contest entitled “New York’s Future As I View It.” It was open to any student in grades 9 through 12 who lived within fifty miles of the Empire State Building. The deadline was April 30, 1965, just days after the World’s Fair reopened in Queens and offered visitors some startling glimpses into the future. (See [Resource 8: The IBM Pavilion at the World’s Fair](#).)

The essays included here are two of the more than 1,000 that were submitted. The collection is now held by the Columbia University Rare Book and Manuscript Library.

The first essay was written by a girl in a Catholic school, the second by a boy in a public school. Both writers were 14 years old and in the ninth grade.

Essay 1

New York's future, as I view it, is a bright one. It depends on today's youth, the creators of tomorrow. What start out as their dreams will, through hard work, be turned into a reality. Only they can solve the problems of tomorrow's cities. New work will be done on today's social problems, including racial prejudice and juvenile delinquency, as well as other problems concerning industry or the population.

The city limits will extend to contain the new, taller apartment buildings built near the city limits to hold the growing population. Bustling suburbs will be connected to the city by high speed bus-trains traveling at 95 miles per hour. Some who do not live near a railroad station can hop into the family helicopter and travel to one of many heliports. Within the city monorails and moving sidewalks offer transportation.

Superskyscrapers will house offices and warehouses. Materials can be shipped between the manufacturers and the warehouses by means of underground conveyor belts for freight. Business men can hold conferences, though widely separated, by means of picture telephones.

New machines will ease the burdens of the individual New Yorker. A future housewife with a microwave oven will be able to cook a full meat dinner in just ten minutes. Other jobs in both the office and the home will become just as easy with the use of futuristic equipment.

The social life of New York will also grow. With the increased standard of living, people will have more money to spend and more leisure time. They will be able to travel with greater ease on their vacations, due to the improved methods of transportation, including the self-controlled automobile. New music will be popular, while pop art will be replaced by a more modern type of art.

More important even than these achievements is the task of solving the problems of the future era. Giant sea walls will be built to protect New York's huge harbor. Answers will be found to the problems of smog and water pollution. Housing problems will be solved by building taller apartment buildings. Children will grow up better, due to this better housing and also to the increasingly superior nutrition they obtain. In the future facilities will be provided to guarantee more and better education to all those who can use it.

It is true that New York's future is only a dream, a whisper in man's mind, but by turning these dreams into reality, New York in the future will become a better city.

-2-

Essay 2

NEW YORK CITY, 2000

The year is 2000. Fifth Avenue isn't the same as it used to be, forty years ago. The Empire State Building, one of the smallest buildings in New York City is still the one hundred and two stories that used to be so tremendous. One can't see the top of some of the taller buildings. There must be hundreds of cars on the new twelve-lane highways. The pedestrians take a footbridge over the crowded streets in order to cross.

During the day it gets very hot on the streets of New York in the summer, but every building is centrally air conditioned. On the streets you never see the sun, unless its directly overhead, because the tall skyscrapers form a non-ending wall on either side of you. Not only do the buildings extend up, but there isn't one that doesn't have at least twenty-five stories underground, where they have every type of store you could imagine.

All along Broadway there are television studios. The new televisions have fifty channels. At any hour of the day they have just about every type of program. There are movies on channels one through ten. Eleven through fifteen; sports. Sixteen to twenty; children's shows. Twenty-one to thirty; quiz games and variety. Thirty-one to thirty-five; news and weather. Thirty-six to fifty; opera, ballet, and concerts. All the programs are in living color. Since 1970 black and white television sets have been off the market.

With picture-phones you can now call anywhere on this earth and be able to see and talk with your party at a price no higher than it used to cost to call the same distance forty years ago. But you are still charged for overcalls (that's why A.T. & T. is still a good investment).

When a child is three he goes to one of New York's most modern elementary school until the seventh grade. Then to high school from eighth to fourteenth grade. After graduating high school, he may

NEW YORK CITY, 2000 #2

go on to college (there are so many more now) where he may choose to study from any of the three hundred professions or vocations that haven't been taken over by automation. The average man works from 10:00 a.m. to 3:00 p.m. with an hour off for lunch. Most of the workers have a higher standard of living compared to the citizens of other countries, and more leisure time for himself and his family. At the age of forty-five he may retire with full social security benefits.

Hundreds of boats dock at the Hudson and East Rivers every day. They bring the exports from countries all over the world, and return with goods that were manufactured in the modern New York City factories. The products aren't touched by human hands until they get to the consumer. At the factories the products are made and packaged by machines. They are taken by truck, train, or monorail to the harbor where they are loaded onto the boats by cranes. The modern ships don't need tugboats to tow them out of shallow harbors.

Doctors have now found cures for every disease known to man. If there is anything wrong with any body organ, surgeons in the most modern hospitals can replace it with an artificial one that comes with a hundred year guarantee. The average lifetime is now about two hundred years.

There is no need to worry about producing enough food for the population because now the food factories in New York City can produce more artificial food in one day than a fifty acre farm with modern machinery could produce in one year. This artificial food is cheaper, but it tastes just as good as the real thing. If it wasn't for the label on the package you couldn't tell that it wasn't grown in the soil. The artificial food can last indefinitely without refrigeration, which is more than you can say for the food products grown on farms. Now the old

farm lands are turned into big industrial cities.

Once again people are flocking to the World's Fair and stare in awe at the wonders of things to come in the years beyond 2000.

TL

**Silicon City:
Computer History Made in
New York**

**CLASSROOM MATERIALS
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SILICON CITY NOW

NEW-YORK
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SOCIETY
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MAKING HISTORY MATTER



NICK VAN WIGGEREN Software Engineer, DigitalOcean
Most of the day, I sit at a computer and write code. I work with about 20 software engineers in a big open space office with a couch in the middle. We're good friends. *We get stuff done but we have fun.*



YI JIAO Designer, Level Solar
My company designs and installs solar panels for houses. I do the blueprints and serve as tech support to the team. *I grew up in Shanghai*, which people call "Asian New York." I wanted to come here because it's like home.



KATHRYN WYLDE President & CEO, Partnership for New York City
New York is a city for this generation of the Internet, *the application generation*. We are not the chipmakers, but we are able to apply technology in ways I think no other city can.



CHARLES E. PHILLIPS CEO, Infor
Half of our management team are women. Three of those are immigrants. We recruit the other ninety-nine percent from schools that aren't Ivy Leagues. *We're changing the face of technology*, at least attempting to.



SALONEE BHAMAN Media Insight Specialist, Dropbox
A lot of bias is subtle. Women are assumed to be better at certain things, like sales, than at others, like tech. You have to become an advocate for yourself, and believe you're entitled to what you want. *Why shouldn't it be me?*

SARAH OLIMPIA SCOTT Software Engineer, Artsy
I'm on a team that makes iOS apps that galleries use to show their work. *I'm trained as an electrical engineer but I've always loved art.* I couldn't work at a job that was only tech.

MARCO VITI Ad Campaign Analyst, Rubicon Projects
I work with ad agencies to find the right place for ads to appear online, on mobile devices, or on videos. This field wasn't around 5 years ago. Now it's a *big business in New York* because the ad agencies are here.

CHAD DICKERSON CEO, Etsy
Young engineers and designers want to work in a place with entertainment and culture and good food. *New York is head and shoulders above* any other place in the world to build a tech company.

DAWN BARBER Co-Founder, New York Tech Meetup
New York Tech Meetup started as a place for people to get together and demo what they were working on. We've stuck to that format. *Show something cool.* Show something new and exciting in tech.

JANAN RAJEEVIKARAN Product Manager, Google
I first experimented with building computers at age 15. At age 21, I bought a book on how to build iPhone apps and built my first app in a month. My advice for kids interested in technology is to *start tinkering. You'll learn a lot.*







© AT&T is proud to support the Silicon City classroom curriculum and highlight the stories of pioneering women throughout the history of technology as part of the company's steadfast commitment to supporting STEM education.

Air View of Manhattan Looking North, 1962. The New-York Historical Society, Thomas Airview Collection. Personal photographs courtesy of Dawn Barber, Salonee Bhaman, Chad Dickerson, Yi Jiao, Charles E. Phillips, Janan Rajeevikaran, Sarah Olimpia Scott, Marco Viti, Nick Van Wiggeren, and Kathryn Wyld.

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Appendix: Glossary

algorithm. A set of rules that tell a machine or software how to carry out a series of steps.

avatar. A graphic image that represents a person, or personalizes a machine.

binary. A system of numbers using only two digits, 0 and 1. See [Writing Numbers in Binary: An Infographic](#).

bit. A binary digit, either 1 or 0. The smallest unit of computer data.

byte. A string of bits that a computer handles as a unit. Today, most bytes are eight bits long.

chip. A small piece of semiconducting material, usually silicon, on which many integrated circuits are embedded. Also called a microchip.

COBOL. The **CO**mmon **B**usiness **O**riented **L**anguage, the first standardized computer language, co-invented and promoted by Grace Hopper.

code. As a noun, a system of signals for communicating, or a set of instructions for a computer. As a verb, “to code” means to write a computer program.

calculator. A device that can add, subtract, multiply, and divide.

coding. The writing of a computer program; synonym for programming.

computer. An electronic device that can receive data, perform calculations and many other functions, and display results.

computer-generated imagery (CG). The use of computer graphics to create special effects in films.

debug. To repair problems in a computer’s hardware or software.

digital. A word broadly used to describe computers and computer technology. Specifically, it refers to a system in which data is conveyed in discreet numerical units, the 1s and 0s of a computer code.

electromechanical. Refers to a mechanical device operated by electricity. A window fan, for example, is electromechanical. So were the relays, or switches, used in early computers. (See electronic.)

electronic. Refers to a device that uses high-speed electrons to switch an electrical current on and off. In the 1940s, IBM’s

Selective Sequence Electronic Calculator (SSEC) was a combination of electronic (the vacuum tubes) and electromechanical (the relay switches). Computers today are entirely electronic, with integrated circuits in place of vacuum tubes.

FORTRAN. A computer programming language introduced by IBM in 1957. It was developed for calculating numbers and formulas, making it ideal for scientists and engineers. The term is an acronym of **FOR**mula **TRAN**slating.

hardware. The physical parts of a computer, like the monitor and keyboard.

integrated circuit. A device, invented in 1958, that today allows millions of transistors to be etched on layers of silicon. Transistors and integrated circuits led the way to the miniaturization of computer technology.

microchip. A tiny wafer of semiconducting material, usually silicon, that holds many integrated circuits.

personal computer. A desktop computer that conformed to IBM’s standards for the IBM

5150, which IBM labeled a PC, or personal computer.

pixel. A shortening of “picture element,” referring to the smallest amount of light visible on a computer monitor.

programmer. A person who writes the instructions that a computer follows to do a task.

programming language. Any one of several systems that provide instructions to a computer. COBOL and FORTRAN are two of the oldest programming languages. Javascript is one of the most popular. Google’s Go is one of the newest.

punched card. A piece of thin cardboard that could be punched with holes to convey and store data. A version of the system dates to the 1700s, but IBM perfected the punched card in the early twentieth century, and revolutionized the way America’s businesses and government operated. Obsolete today, punched-card technology was an essential step in the development of the electronic computer.

semiconductor. A solid material that can be made to either

conduct or block the flow of electricity. The most common semiconductor in computers is silicon, the basis of transistors and integrated circuits.

silicon. A semiconducting material found in sand. In computer manufacturing today, tiny chips of silicon are etched with transistors and built in layers to form integrated circuits.

software. A program of instructions for a computer.

transistor. A device invented by Bell Labs in 1947 to replace vacuum tubes. A decade later, the invention of the integrated chip made it possible to etch millions of transistors on a tiny wafer of silicon.

vacuum tube. A device created by physicist John Fleming, based on an earlier observation by Thomas Edison. It was the voltage regulator and current amplifier in radios and other electronic devices for much of the twentieth century, and the on/off switch in early computers. Valuable as it was, it was also unreliable, hot, and bulky. It was replaced by the transistor and integrated circuit.

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Bell Labs

www.bell-labs.com/about/stories-changed-world/future-impossible-video-series/

A website offering several short films about technology.

Black Girls Code

www.blackgirlscode.com

A website devoted to providing young and pre-teen girls of color opportunities to learn in-demand skills in technology and computer programming.

Code.org <https://code.org/>

A website focused on expanding access to technology for women and minorities, with “how to code” activities for students and educators.

Computer History Collection

National Museum of American History, Smithsonian Institution. americanhistory.si.edu/comphist/ With links to selected audio interviews of computer pioneers.

Computer History Museum

www.computerhistory.org Online exhibits, biographies of the Hall of Fellows honorees since 1987, and many other features.

CS First www.cs-first.com/ Google's free computer science site for students or teachers starting a coding club at their school.

1890 Census

www.census.gov/history/www/through_the_decades/questionnaires/1890_2.html For a blank schedule from the 1890 U.S. Census.

“The First Video Game?”

Brookhaven National Laboratory. www.bnl.gov/about/history/firstvideo.php The history of the 1958 game later dubbed “Tennis for Two.”

“The Forgotten Female Programmers Who Created Modern Tech”

www.npr.org/sections/alltechconsidered/2014/10/06/345799830/the-forgotten-female-programmers-who-created-modern-tech

An NPR piece, with audio and text, that examines women's roles in technology, from Ada Lovelace, daughter of Lord Byron, to Grace Hopper.

Girls Who Code

www.girlswhocode.com

A national nonprofit organization working to close the gender gap in the technology and engineering sectors.

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The World Video Game Hall of Fame, National Museum of Play

www.worldvideogamehalloffame.org/ First inductees, welcomed in 2015, were Pong, DOOM, Pac-Man, Super Mario Bros., Tetris, and World of Warcraft.

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Appendix: New York State Social Studies Framework

Grade 8

Standards:

Standard 1: History of the United States and New York

Students will use a variety of intellectual skills to demonstrate their understanding of major ideas, eras, themes, developments, and turning points in the history of the United States and New York.

Standard 2: World History

Students will use a variety of intellectual skills to demonstrate their understanding of major ideas, eras, themes, developments, and turning points in world history and examine the broad sweep of history from a variety of perspectives.

Standard 4: Economics

Students will use a variety of intellectual skills to demonstrate their understanding of how the United States and other societies develop economic systems and associated institutions to allocate scarce resources, how major decision-making units function in the United States and other national economies, and how an economy solves the scarcity problem through market and nonmarket mechanisms.

Standard 5: Civics, Citizenship, and Government

Students will use a variety of intellectual skills to demonstrate their understanding of the necessity for establishing governments; the governmental systems of the United States and other nations; the United States Constitution; the basic civic values of American constitutional democracy; and the roles, rights, and responsibilities of citizenship, including avenues of participation.

Key Ideas:

Key Idea 2: A CHANGING SOCIETY: Industrialization and immigration contributed to the urbanization of America. Problems resulting from these changes sparked the Progressive movement and increased calls for reform.

8.2b Population density, diversity, technologies, and industry in urban areas shaped the social, cultural, and economic lives of people.

X

Key Idea 6: WORLD WAR II: The aggression of the Axis powers threatened United States security and led to its entry into World War II. The nature and consequences of warfare during World War II transformed the United States and the global community. The damage from total warfare and atrocities such as the Holocaust led to a call for international efforts to protect human rights and prevent future wars.

8.6b From 1939 to 1941, the United States government tried to maintain neutrality while providing aid to Britain but was drawn into the war by the Japanese attack on Pearl Harbor. The United States fought a war on multiple fronts. At home, the economy was converted to war production, and essential resources were rationed to ensure adequate supplies for military use.

X

Key Idea 7: FOREIGN POLICY: The period after World War II has been characterized by an ideological and political struggle, first between the United States and communism during the Cold War, then between the United States and forces of instability in the Middle East. Increased economic interdependence and competition, as well as environmental concerns, are challenges faced by the United States.

8.7e Increased globalization has led to increased economic interdependence and competition.

X

Key Idea 8: DEMOGRAPHIC CHANGE: After World War II, the population of the United States rose sharply as a result of both natural increases and immigration. Population movements have resulted in changes to the American landscape and shifting political power. An aging population is affecting the economy and straining public resources.

8.8a After World War II, the United States experienced various shifts in population and demographics that resulted in social, political, and economic consequences.

X

Key Idea 9: DOMESTIC POLITICS AND REFORM: The civil rights movement and the Great Society were attempts by people and the government to address major social, legal, economic, and environmental problems. Subsequent economic recession called for a new economic program.

8.9b The civil rights movement prompted renewed efforts for equality by women and other groups.

X

Appendix: New York State Social Studies Framework

Grade 11

Standards:

Standard 1: History of the United States and New York

Students will use a variety of intellectual skills to demonstrate their understanding of major ideas, eras, themes, developments, and turning points in the history of the United States and New York.

Standard 2: World History

Students will use a variety of intellectual skills to demonstrate their understanding of major ideas, eras, themes, developments, and turning points in world history and examine the broad sweep of history from a variety of perspectives.

Standard 4: Economics

Students will use a variety of intellectual skills to demonstrate their understanding of how the United States and other societies develop economic systems and associated institutions to allocate scarce resources, how major decision-making units function in the United States and other national economies, and how an economy solves the scarcity problem through market and nonmarket mechanisms.

Standard 5: Civics, Citizenship, and Government

Students will use a variety of intellectual skills to demonstrate their understanding of the necessity for establishing governments; the governmental systems of the United States and other nations; the United States Constitution; the basic civic values of American constitutional democracy; and the roles, rights, and responsibilities of citizenship, including avenues of participation.

Key Ideas:

Key Idea 3: EXPANSION, NATIONALISM, AND SECTIONALISM (1800 – 1865): As the nation expanded, growing sectional tensions, especially over slavery, resulted in political and constitutional crises that culminated in the Civil War.

11.3a American nationalism was both strengthened and challenged by territorial expansion and economic growth.

X

Key Idea 5: INDUSTRIALIZATION AND URBANIZATION (1870 – 1920): The United States was transformed from an agrarian to an increasingly industrial and urbanized society. Although this transformation created new economic opportunities, it also created societal problems that were addressed by a variety of reform efforts.

11.5a New technologies and economic models created rapid industrial growth and transformed the United States.

Key Idea 8: 11.8. WORLD WAR II (1935 – 1945): The participation of the United States in World War II was a transformative event for the nation and its role in the world.

11.8b United States entry into World War II had a significant impact on American society.

X

Key Idea 9: COLD WAR (1945 – 1990): In the period following World War II, the United States entered into an extended era of international conflict called the Cold War which influenced foreign and domestic policy for more than 40 years.

11.9b The United States and the Soviet Union engaged in a nuclear arms race that eventually led to agreements that limited the arms buildup and improved United States-Soviet relations.

X

Key Idea 10: SOCIAL AND ECONOMIC CHANGE/DOMESTIC ISSUES (1945 – present): Racial, gender, and socioeconomic inequalities were addressed by individuals, groups, and organizations. Varying political philosophies prompted debates over the role of the federal government in regulating the economy and providing a social safety net.

11.10b Individuals, diverse groups, and organizations have sought to bring about change in American society through a variety of methods.

X

Appendix: Common Core Standards

Literacy in History/Social Studies—Grades 7 & 8

Key Ideas and Details	
1) Cite specific textual evidence to support analysis of primary and secondary sources.	X
2) Determine the central ideas or information of a primary or secondary source; provide an accurate summary of the source distinct from prior knowledge or opinions.	X
3) Identify key steps in a text's description of a process related to history/social studies (e.g., how a bill becomes law, how interest rates are raised or lowered).	X
Craft and Structure	
4) Determine the meaning of words and phrases as they are used in a text, including vocabulary specific to domains related to history/social studies.	X
5) Describe how a text presents information (e.g., sequentially, comparatively, causally)	X
6) Identify aspects of a text that reveal an author's point of view or purpose (e.g., loaded language, inclusion or avoidance of particular facts)	X
Integration of Knowledge and Ideas	
7) Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.	X
8) Distinguish among fact, opinion, and reasoned judgment in a text.	X
9) Analyze a case in which two or more texts provide conflicting information on the same topic and identify where the texts disagree on matters of fact or interpretation.	X
Range of Reading and Level of Text Complexity	
10) By the end of grade 8, read and comprehend history/social studies texts in the grades 6–8 text complexity band independently and proficiently.	X

Appendix: Common Core Standards

Literacy in History/Social Studies—Grade 11

Key Ideas and Details	
1) Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.	X
2) Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.	X
3) Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain.	X
Craft and Structure	
4) Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10).	X
5) Analyze in detail how a complex primary source is structured, including how key sentences, paragraphs, and larger portions of the text contribute to the whole.	X
6) Evaluate authors' differing points of view on the same historical event or issue by assessing the authors' claims, reasoning, and evidence.	X
Integration of Knowledge and Ideas	
7) Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.	X
8) Evaluate an author's premises, claims, and evidence by corroborating or challenging them with other information.	X
9) Integrate information from diverse sources, both primary and secondary, into a coherent understanding of an idea or event, noting discrepancies among sources.	X
Range of Reading and Level of Text Complexity	
10) By the end of grade 12, read and comprehend history/social studies texts in the grades 11–CCR text complexity band independently and proficiently.	X

Appendix: Common Core Standards

Literacy in Science and Technical Subjects—Grades 7 & 8

Key Ideas and Details	
1) Cite specific textual evidence to support analysis of science and technical texts.	X
2) Determine the central ideas or information of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.	X
3) Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.	X
Craft and Structure	
4) Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.	X
6) Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.	X
Integration of Knowledge and Ideas	
7) Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	X
9) Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	X
Range of Reading and Level of Text Complexity	
10) By the end of grade 8, read and comprehend science/technical texts in the grades 6–8 text complexity band independently and proficiently.	X

Appendix: Common Core Standards

Literacy in Science and Technical Subjects—Grade 11

Key Ideas and Details	
2) Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	X
3) Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.	X
Craft and Structure	
4) Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.	X
5) Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of information or ideas.	X
6) Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.	X
Integration of Knowledge and Ideas	
7) Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.	X
9) Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.	X
Range of Reading and Level of Text Complexity	
10) By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently.	X

Appendix: New York City Blueprint for Teaching and Learning in Visual Arts

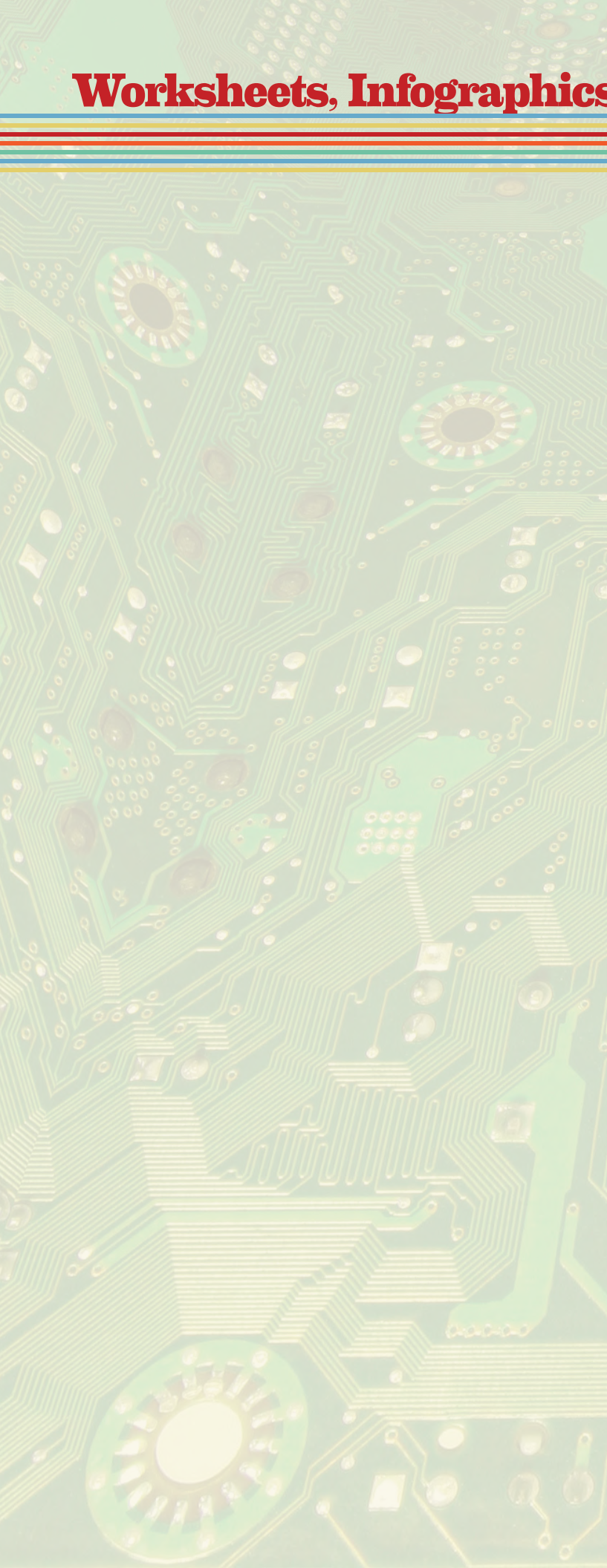
Grade 8

Art Making Benchmark: Through close observation and sustained investigation, students develop individual and global perspectives on art; utilize the principles of art; solve design problems; and explore perspective, scale and point of view.		Community and Cultural Resources Benchmark: By working with a variety of school staff, students access primary resources in the community, the borough, and the city to extend their learning beyond the classroom.	
Painting	X	Cultural Institutions	X
Drawing	X	Public Art and Design	X
Printmaking	X	Online Resources and Libraries	X
Collage	X	Exploring Careers and Lifelong Learning Benchmark: Students gain an awareness of careers in visual arts; recognize personal, social and professional goals; develop a career plan; learn to work independently and in teams; gain an appreciation of art as a source of enjoyment and lifelong learning.	
Sculpture	X	Awareness of Careers in Visual Arts	X
2D/Graphic Design	X	Setting Goals and Developing Career Plans	X
Digital Media	X	Art of Enjoyment and Lifelong Learning	X
Developing Art Literacy Benchmark: Students hone observation skills and discuss works of art; develop visual arts vocabulary to describe art making, the tools and techniques used to produce art, and the elements and principles of design; read and write about art to reinforce literacy skills; interpret artwork by providing evidence to support assertions; reflect on the process of making art.			
Looking at and Discussing Art	X		
Developing Visual Arts Vocabulary	X		
Reading and Writing about Art	X		
Problem Solving: Interpreting and Analyzing Art	X		
Making Connections Through Visual Arts Benchmark: Students recognize the societal, cultural, and historical significance of art; connect the visual arts to other disciplines; apply the skills and knowledge learned in visual arts to interpreting the world.			
Recognizing the Societal, Cultural, and Historical Significance of Art; Connecting Art to Other Disciplines	X		
Observing and Interpreting the World	X		

Appendix: Blueprint for Teaching and Learning in Visual Arts

Grade 11

Art Making Benchmark: In a three-year major art sequence, students master various materials and techniques to develop a portfolio that reflects a personal style and the awareness of the power of art to illuminate, inform, and influence opinion.		Community and Cultural Resources Benchmark: By working with a variety of school staff, students access primary resources in the community, the borough, and the city to extend their learning beyond the classroom.	
Painting	X	Cultural Institutions	X
Drawing	X	Public Art and Design	X
Printmaking	X	Online Resources and Libraries	X
Collage	X	Exploring Careers and Lifelong Learning Benchmark: Students gain an awareness of careers in visual arts; recognize personal, social and professional goals; develop a career plan; learn to work independently and in teams; gain an appreciation of art as a source of enjoyment and lifelong learning.	
Sculpture	X	Awareness of Careers in Visual Arts	X
2D/Graphic Design	X	Setting Goals and Developing Career Plans	X
Digital Media	X	Art of Enjoyment and Lifelong Learning	X
Developing Art Literacy Benchmark: Students hone observation skills and discuss works of art; develop visual arts vocabulary to describe art making, the tools and techniques used to produce art, and the elements and principles of design; read and write about art to reinforce literacy skills; interpret artwork by providing evidence to support assertions; reflect on the process of making art.			
Looking at and Discussing Art	X		
Developing Visual Arts Vocabulary	X		
Reading and Writing about Art	X		
Problem Solving: Interpreting and Analyzing Art	X		
Making Connections Through Visual Arts Benchmark: Students recognize the societal, cultural, and historical significance of art; connect the visual arts to other disciplines; apply the skills and knowledge learned in visual arts to interpreting the world.			
Recognizing the Societal, Cultural, and Historical Significance of Art; Connecting Art to Other Disciplines	X		
Observing and Interpreting the World	X		



Worksheets, Infographics, and Printable Resources

Worksheets.....	78
Infographics.....	84
Printable Resources.....	86

Name: _____

Binary Worksheet

Aim: To understand the language that computers use, and how it works.

Do now: Fill in the chart

$2^7=$	$2^6=$	$2^5=$	$2^4=$	$2^3=$	$2^2=$	$2^1=$	$2^0=$

Convert from Decimal to Binary

Decimal (Base 10)	Binary (Base 2)	Show your work!
1		
2		
5		
8		
9		
12		
13		
14		
17		
200		
256		
511		
512		
1023		
1024		
2048		

Ben Samuels-Kalow 2015

Convert from Binary to Decimal

Binary (Base 2)	Decimal (Base 10)	Show your work!
01		
10		
100		
101		
1101		
111		
11		
110		
1111		
11111		
10111		
10101		
01010		
01110		
01100		
00010		

Reflection:

Describe your method to convert decimal numbers into binary, and from binary into decimal.

Were you **faster** at converting from base 10 to base 2 or base 2 to base 10? Why do you think that is?

Why do you think most civilizations use a decimal (Base 10) system?

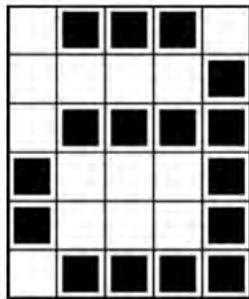
Why do computers use binary (base 2)?

What are we **better** at than a computer?

Name: _____

Binary Run Length Image Encoding

This picture shows us how a picture can be represented by numbers. The first line consists of one white pixel, then three black, then one white. Thus the first line is represented as 1, 3, 1. The letter “a” has been magnified below to show the pixels. When a computer stores a picture, all that it needs to store is which dots are black and which are white.



1, 3, 1

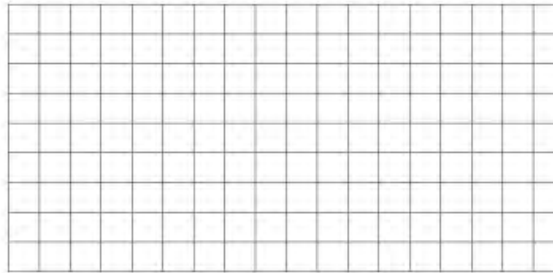
4, 1

1, 4

0, 1, 3, 1

0, 1, 3, 1

1, 4



4, 11

4, 9, 2, 1

4, 9, 2, 1

4, 11

4, 9

4, 9

5, 7

0, 17

1, 15

Now you will try to **decode** these images.

The **first** number always relates to the number of **white** pixels. If the **first** pixel is black the line will begin with a **zero**.



6, 5, 2, 3

4, 2, 5, 2, 3, 1

3, 1, 9, 1, 2, 1

3, 1, 9, 1, 1, 1

2, 1, 11, 1

2, 1, 10, 2

2, 1, 9, 1, 1, 1

2, 1, 8, 1, 2, 1

2, 1, 7, 1, 3, 1

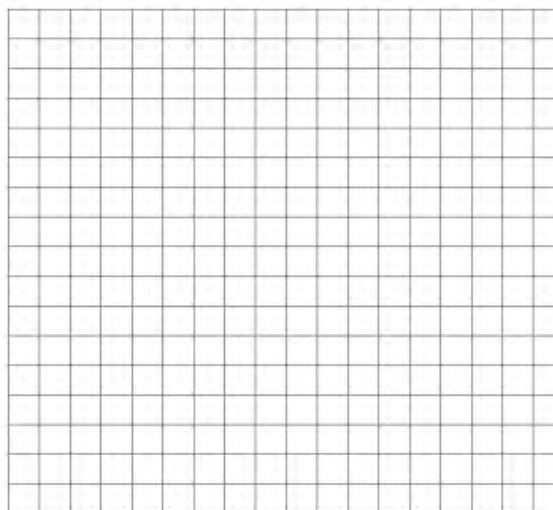
1, 1, 1, 1, 4, 2, 3, 1

0, 1, 2, 1, 2, 2, 5, 1

0, 1, 3, 2, 5, 2

1, 3, 2, 5

Computer screens are divided up into a grid of small dots called **pixels** (picture elements). In a black and white picture, each pixel is either black or white.



6, 2, 2, 2

5, 1, 2, 2, 2, 1

6, 6

4, 2, 6, 2

3, 1, 10, 1

2, 1, 12, 1

2, 1, 3, 1, 4, 1, 3, 1

1, 2, 12, 2

0, 1, 16, 1

0, 1, 6, 1, 2, 1, 6, 1

0, 1, 7, 2, 7, 1

1, 1, 14, 1

2, 1, 12, 1

2, 1, 5, 2, 5, 1

3, 1, 10, 1

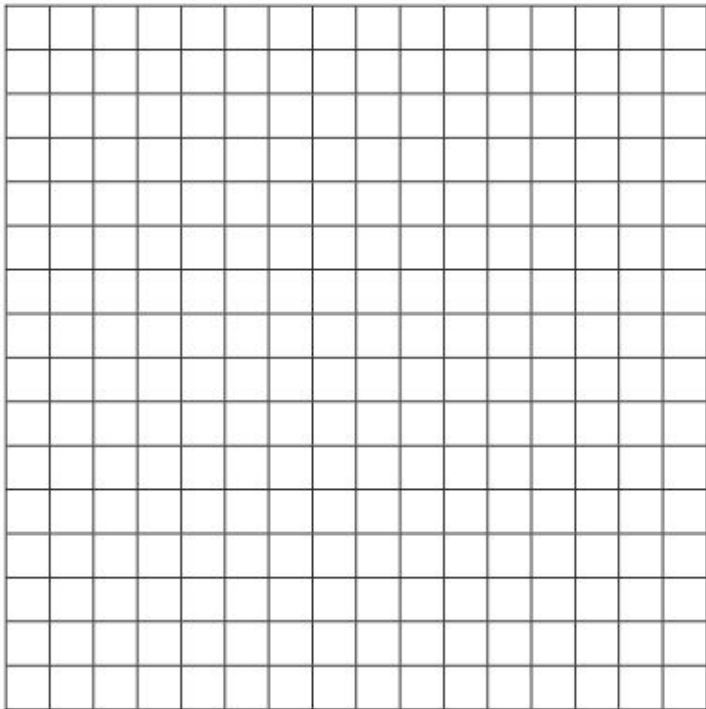
4, 2, 6, 2

6, 6

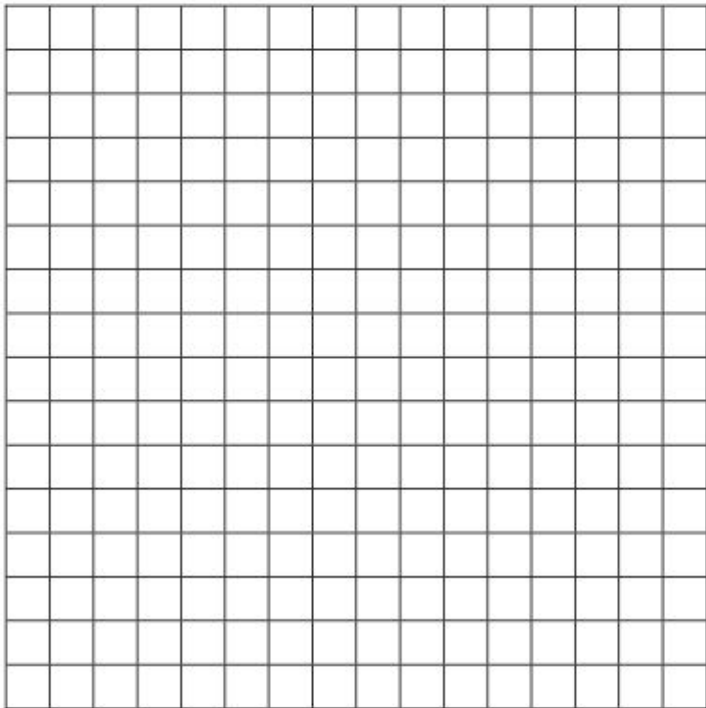
The first picture is the easiest and the last one is the most complex. It is easy to make mistakes and therefore a good idea to use a pencil to color with and have an eraser handy.

Ben Samuels-Kalow 2015

Now that you know how numbers can represent pictures, you will encode a picture for a partner. Draw your picture on the top grid, and when you've finished, write the code numbers beside the bottom grid. Fold along the line and give the bottom grid to a friend to color in. (Note: you don't have to use the whole grid if you don't want to—just leave some blank lines at the bottom if your picture doesn't take up the whole grid.)



15 horizontal lines for writing code numbers.



15 horizontal lines for writing code numbers.

Name: _____

Date: _____

Image Study

Examine your image carefully and list or sketch your observations in the boxes below.

OBJECTS/PEOPLE

DETAILS

Image Citation Information:

Title: _____

Artist: _____

Date: _____

1. What is the subject of this image? _____

2. Write a one sentence summary of the story of this image:

3. How does this image make you feel about the subject? How did the artist achieve that effect?

4. What does this image reveal about the history of computers?

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Name: _____

Date: _____

Text Study

PART I: The Big Picture

1. Examine the citation for the document and record the following information:

Title: _____

Author: _____

Date: _____

2. Read through the document once and summarize the main idea of the document in two or three complete sentences.

3. Record any unfamiliar words you found in the document so you can look them up later.

PART II: Digging Deeper

Read the document through again and answer the following questions:

1. Is this a work of fiction or non-fiction? How do you know?

2. What does this document reveal about how people regarded computers and robots in 1950? How do you know?

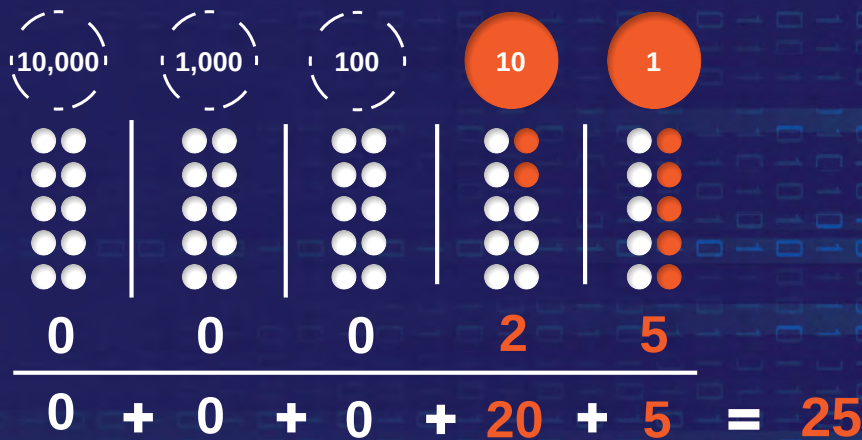
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Writing Numbers in Binary

In **Decimal**,
everything is based on **10**

We write numbers using columns that increase by 10 times (1s, 10s, 100s, 1,000s, etc). Each column can hold 10 digits (0-9).

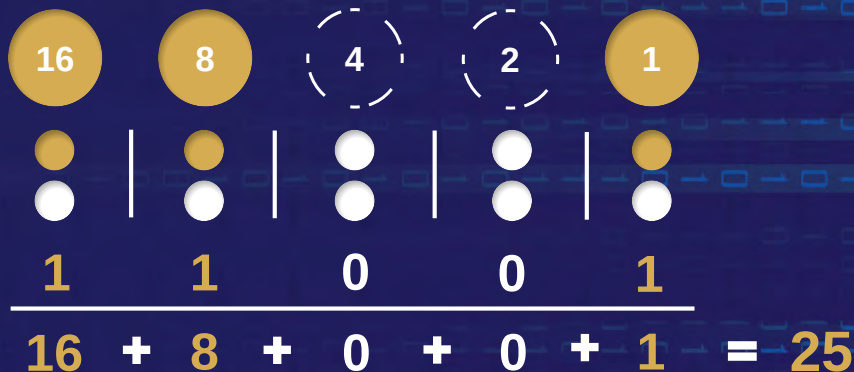
Twenty-Five in Decimal is **25**



In **Binary**,
everything is based on **2**

We write numbers using columns that increase by 2 times (1s, 2s, 4s, 8s, 16s, etc). Each column can hold 2 digits (0 or 1).

Twenty-Five in Binary is **11001**



A Computer in Your Pocket

Computers have steadily shrunk in size and cost even as they've grown faster and more powerful.

Gordon Moore, co-founder of Intel, foresaw this. He predicted in 1965 that the number of transistors squeezed onto an integrated circuit would increase exponentially, doubling roughly every year. "Moore's Law" has held generally true for half a century, now doubling about every two years or so.

1965



2015



**Your Smartphone beats a
\$5,000,000 1960s computer
(And is easier to carry.)**

©Chris, Full Length View of Little Girl Standing, Holding Smartphone, Date is a
Images Courtesy of Shutterstock



Resource 1: ★ Hollerith's Electrical Tabulating Machine

Scientific American, cover, August 30, 1890. Library of Congress, Prints and Photographs Division, LC-USZ62-58724.

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Day	12 Mo	I C C Acct. No.	Shop No.	Engine or Shop Order No.	Check No.	Occupation Craft No.	Detail Description of Operation	Quantity	Hours	Rate	Amount
00	10	0000	00	00000000	000000	000000	000000	000000	0000	0000	00000000
11	1	1111	11	11111111	111111	111111	111111	111111	11	1111	11111111
22	2	2222	22	22222222	222222	222222	222222	222222	22	2222	22222222
33	3	3333	33	33333333	333333	333333	333333	333333	33	3333	33333333
15	4	4444	44	44444444	444444	444444	444444	444444	44	4444	44444444
16	5	5555	55	55555555	555555	555555	555555	555555	55	5555	55555555
66	6	6666	66	66666666	666666	666666	666666	666666	66	6666	66666666
18	7	7777	77	77777777	777777	777777	777777	777777	77	7777	77777777
19	8	8888	88	88888888	888888	888888	888888	888888	88	8888	88888888
20	9	9999	99	99999999	999999	999999	999999	999999	99	9999	99999999

[illegible][illegible]

87

The Three Laws of Robotics

- 1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.**
- 2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.**
- 3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.**

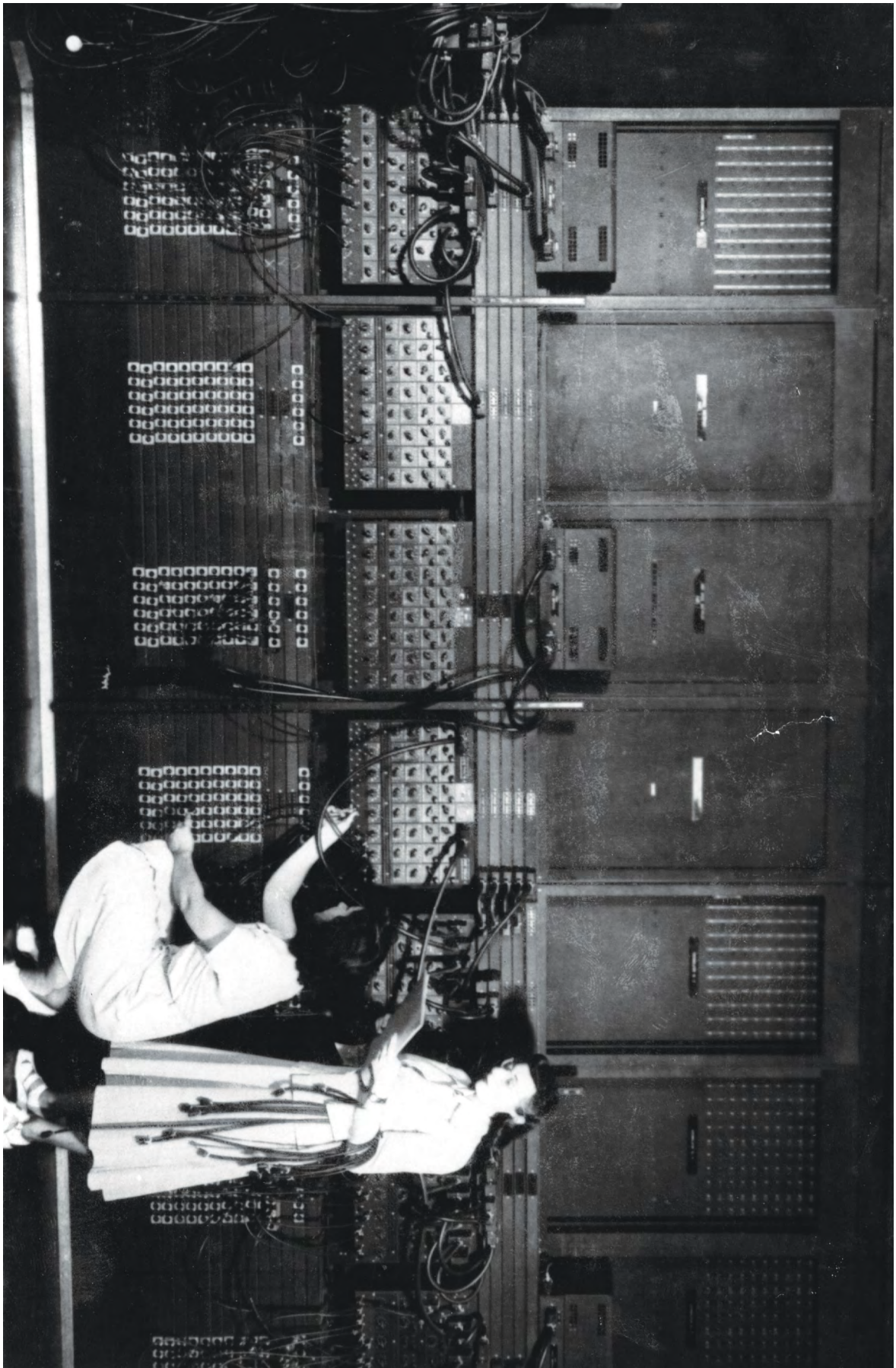
Handbook of Robotics, 56th Edition, 2058 A.D.

Resource 3: The Three Laws of Robotics

"Three Laws of Robotics" from I, ROBOT by Isaac Asimov, copyright © 1950 by Isaac Asimov. Used by permission of Bantam Books, an imprint of Random House, a division of Penguin Random House LLC. All rights reserved.

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Resource 4: ★ Women Programmers of ENIAC

Marilyn Wescoff Meltzer (1922–2008) and Ruth Lichterman Teitelbaum (1924–1986) Wiring the Right Side of ENIAC, ca. 1946. Reproduction Courtesy of the U.S. Army.

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Resource 5: The Transistor

(Left to right) John Bardeen, William Shockley, and Walter Brattain, June 1948. Courtesy of Alcatel-Lucent/Bell Labs.

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Resource 6: Walter Cronkite and UNIVAC

J. Presper Eckert Explains UNIVAC to Walter Cronkite, ca. 1952.
Courtesy of the Computer History Museum, #102621829, Lot #7413.2015.

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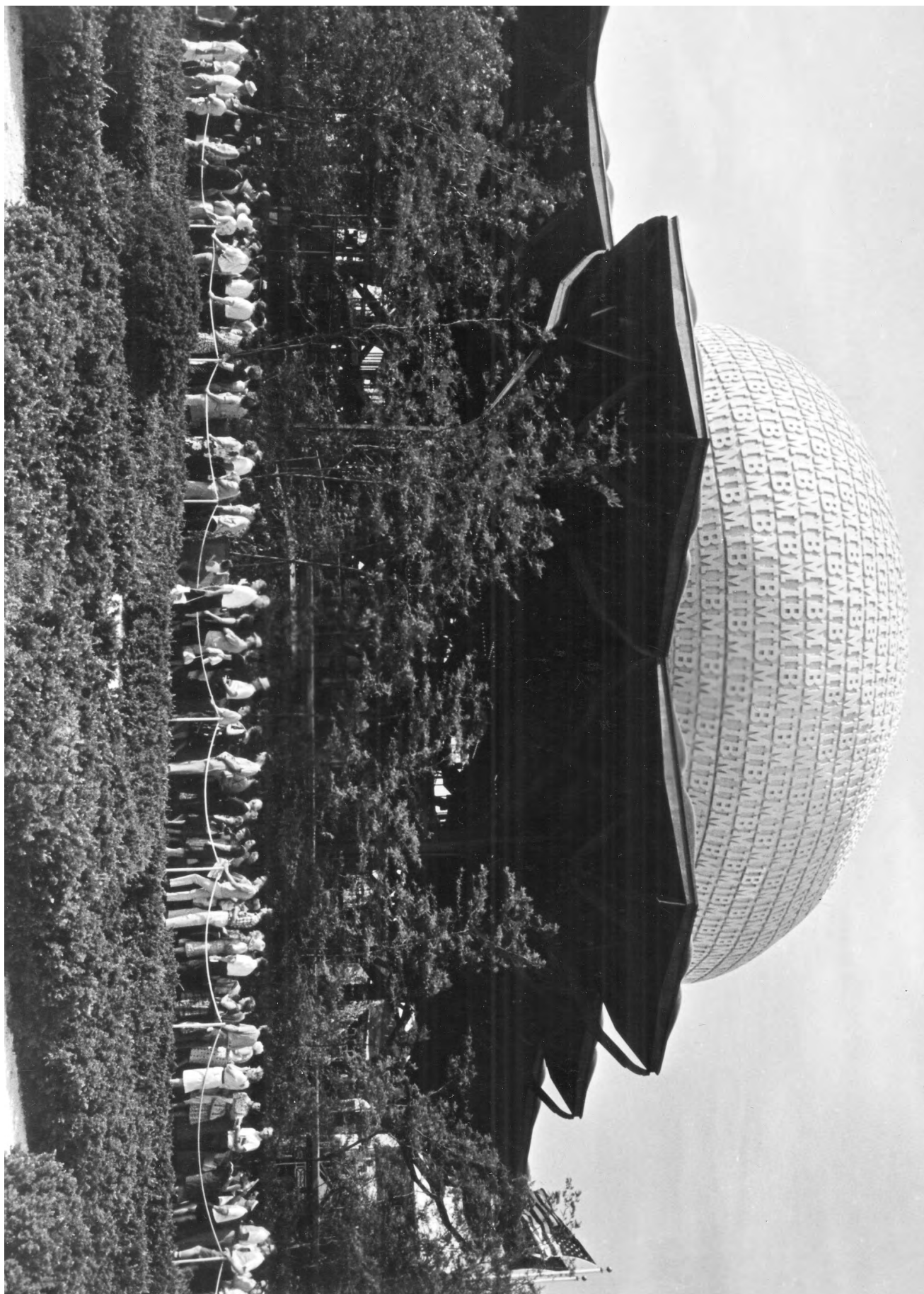


Resource 7: The First Transatlantic Telephone Cable

AT&T, Transatlantic Telephone Cable (TAT-1) Pulled Ashore at Clarendville, Newfoundland, ca. 1955.
Reproduction Courtesy of the AT&T Archives and History Center.

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Resource 8: The IBM Pavilion at the World's Fair

New York World's Fair IBM Pavilion, 1964. Courtesy of IBM Corporation Archives.

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Resource 8: The IBM Pavilion at the World's Fair

Unidentified Artist, Opening Ceremonies of Picturephone with Mrs. Lyndon B. Johnson (1912–2007) in Washington Chatting Via See-As-You-Talk Telephone with Robert F. Wagner (1910–1991), Mayor of New York City, and Dr. Elizabeth A. Wood (1912–2006), the First Woman Scientist at Bell Labs, June 24 1964. Courtesy of Alcatel-Lucent/Bell Labs.

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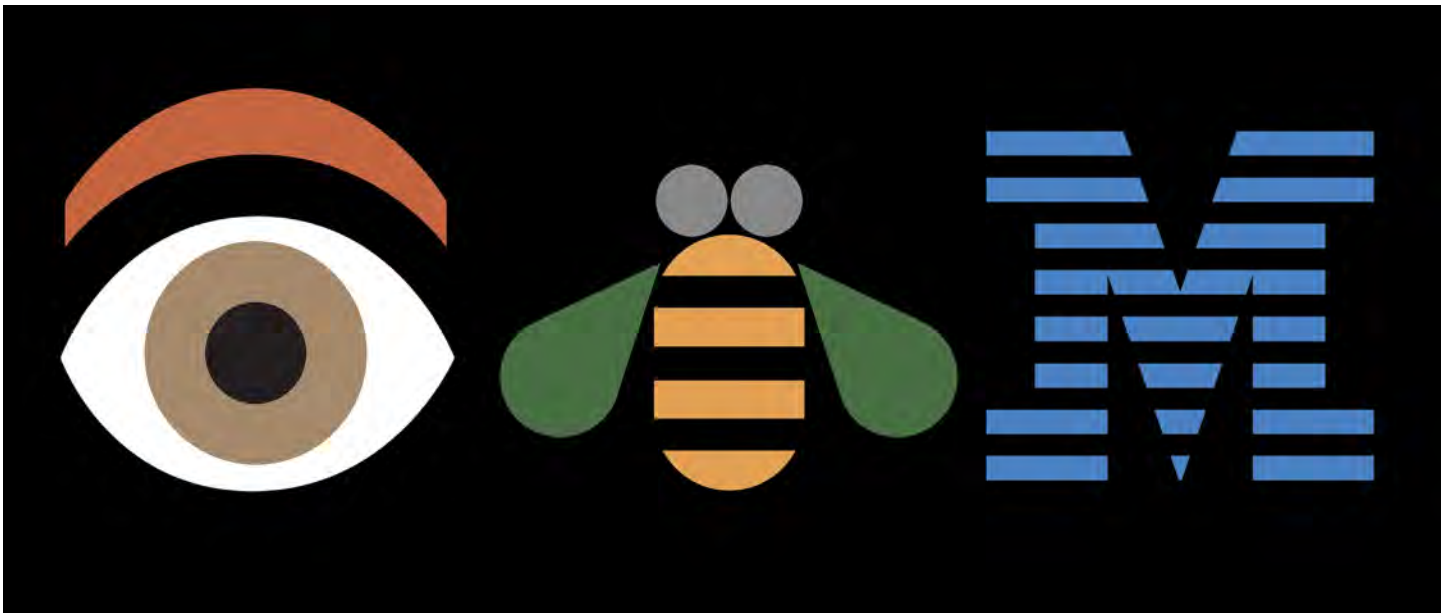


Resource 8: The IBM Pavilion at the World's Fair

IBM Selectric, 1961. Courtesy of IBM Corporation Archives.

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Resource 9: Design and Branding

(top) Paul Rand (1914–1996), Eye Bee M, 1981. Courtesy of IBM Corporation Archives.
 (bottom) Paul Rand (1914–1996), IBM 8 Bar Logo, 1972. Courtesy of IBM Corporation Archives.

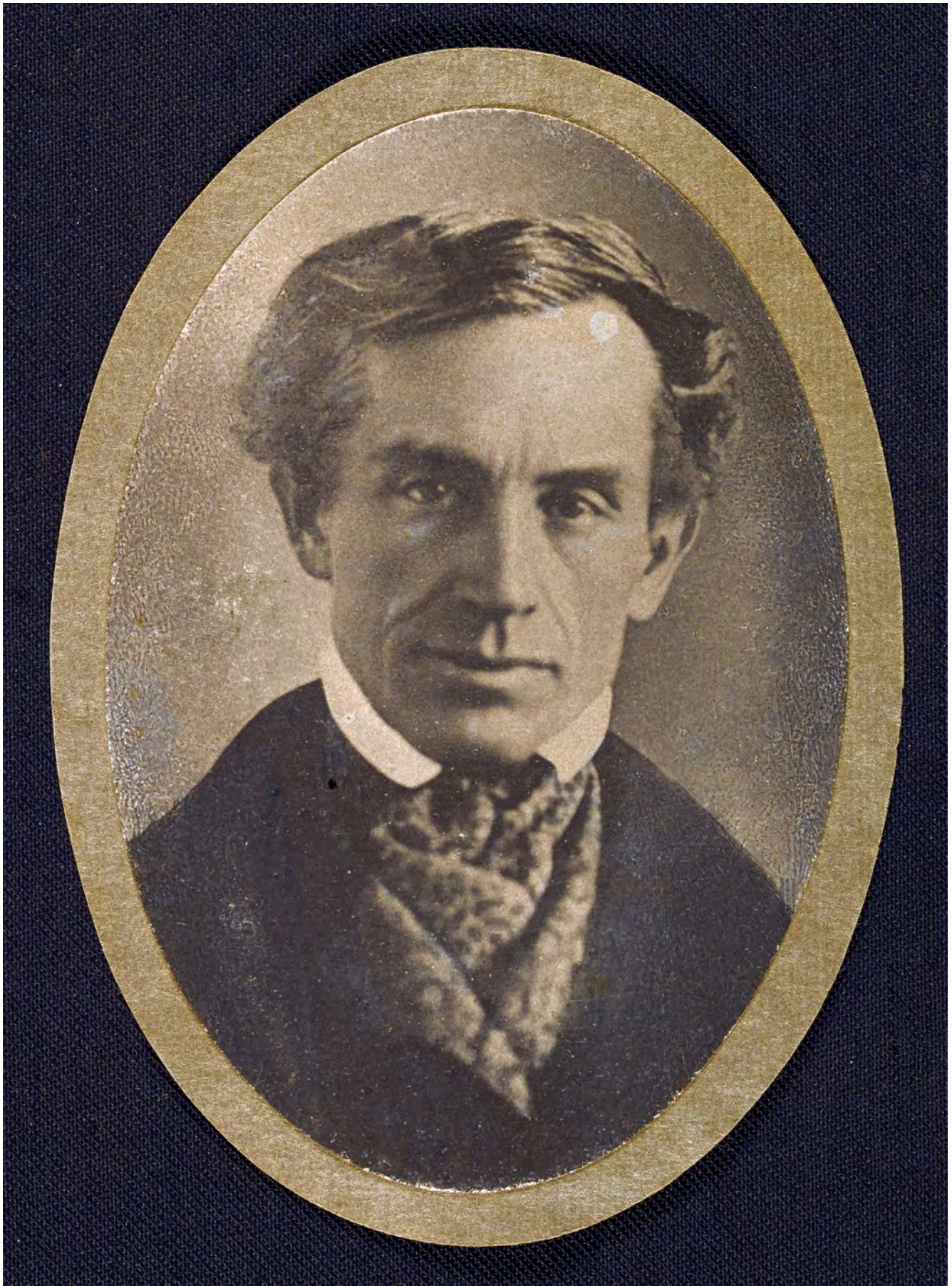


Resource 10: Watson on Jeopardy!

Seth Wenig, Man vs. Machine, January 13, 2011. Associated Press, 11011318225.

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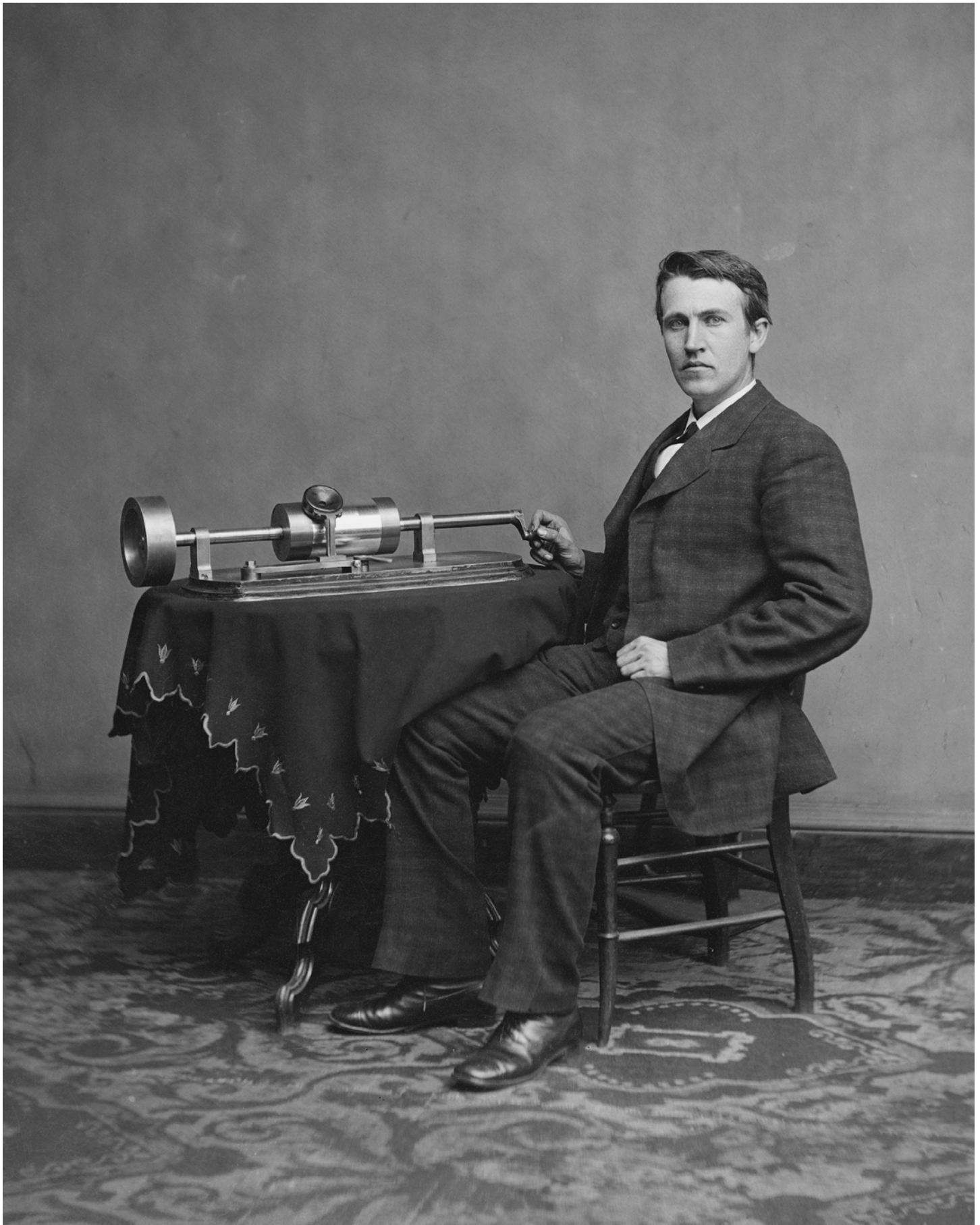


Life Story: Samuel F. B. Morse (1791–1872)

Louis-Jacques-Mandé Daguerre (1787–1851), Portrait of Samuel F. B. Morse (1791–1872), 1840.
Reproduction Archives of American Art, Smithsonian Institution.

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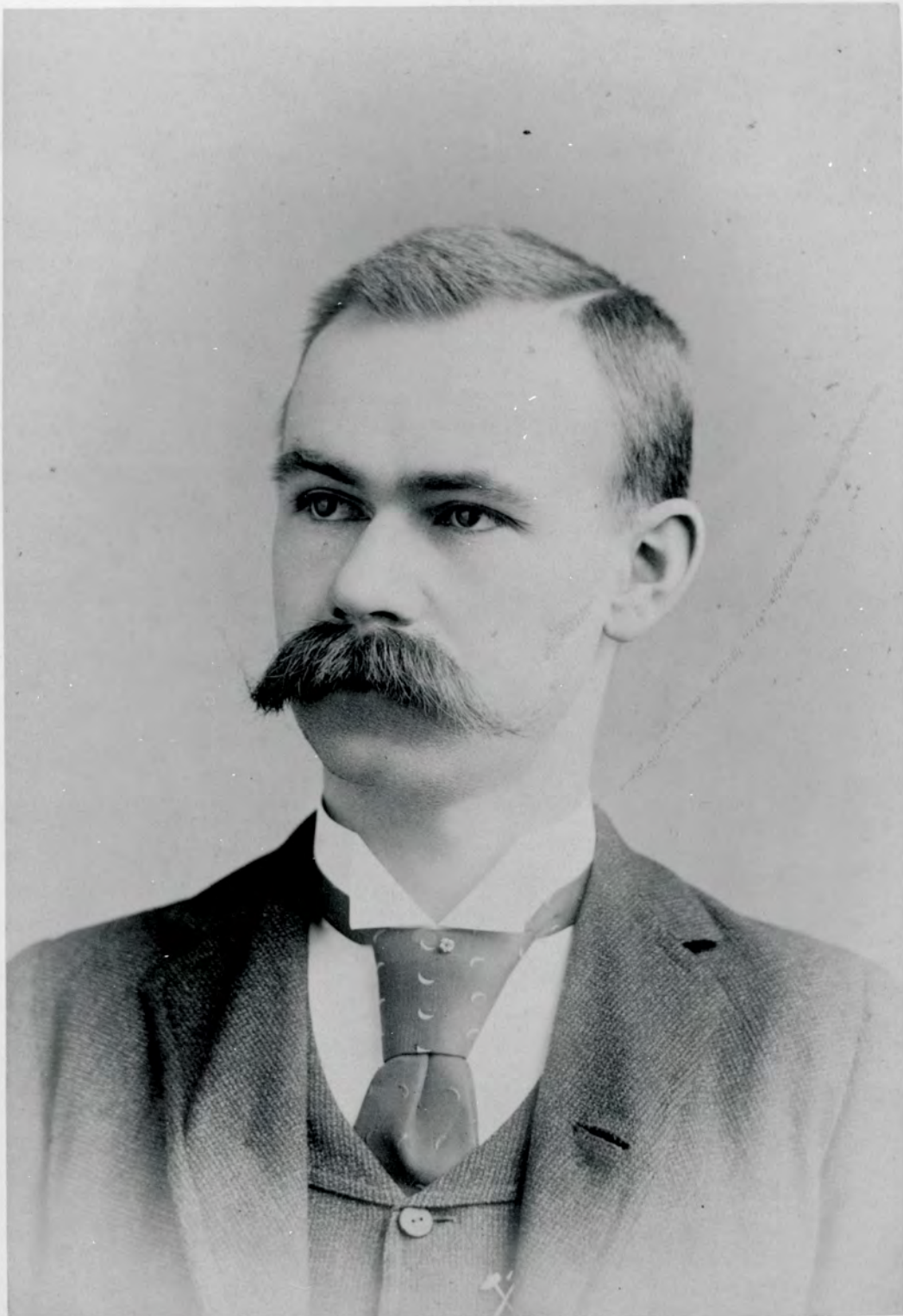


Life Story: Thomas A. Edison (1847–1931)

Mathew B. Brady (1822–1896), Professor Thomas Edison (1847–1931) and His Speaking Phonograph, 1878. Collection of Charley Hummel.

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C. M. Bell

463-465 PENNA. AVENUE,
WASHINGTON, D. C.

Life Story: Herman Hollerith (1860–1929)

C. M. Bell (ca. 1849–1893), Portrait of Herman Hollerith (1860–1929), ca. 1888. Library of Congress, Prints and Photographs Division, C. M. Bell, photographer. LC-USZ62-115982.

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Life Story: ★ Grace Hopper (1906–1992)

Dr. Grace Hopper, Director, Systems Research, Remington Rand, ca. 1961. Library of Congress, Prints and Photographs Division, LC-USZ62-111439.

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**Life Story: Thomas J. Watson, Sr. (1874–1956) and
Thomas J. Watson, Jr. (1914–1993)**

One month before his death on June 19, 1956, IBM Chairman Thomas J. Watson, Sr., (right) hands over the reins of the company to his eldest son, Thomas J. Watson, Jr. (left), 1956. Courtesy of IBM Corporation Archives.

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New York's future, as I view it, is a bright one. It depends on today's youth, the creators of tomorrow. What start out as their dreams will, through hard work, be turned into a reality. Only they can solve the problems of tomorrow's cities. New work will be done on today's social problems, including racial prejudice and juvenile delinquency, as well as other problems concerning industry or the population.

The city limits will extend to contain the new, taller apartment buildings built near the city limits to hold the growing population. Bustling suburbs will be connected to the city by high speed bus-trains traveling at 95 miles per hour. Some who do not live near a railroad station can hop into the family helicopter and travel to one of many heliports. Within the city monorails and moving sidewalks offer transportation.

Superskyscrapers will house offices and warehouses. Materials can be shipped between the manufacturers and the warehouses by means of underground conveyor belts for freight. Business men can hold conferences, though widely separated, by means of picture telephones.

New machines will ease the burdens of the individual New Yorker. A future housewife with a microwave oven will be able to cook a full meat dinner in just ten minutes. Other jobs in both the office and the home will become just as easy with the use of futuristic equipment.

The social life of New York will also grow. With the increased standard of living, people will have more money to spend and more leisure time. They will be able to travel with greater ease on their vacations, due to the improved methods of transportation, including the self-controlled automobile. New music will be popular, while pop art will be replaced by a more modern type of art.

More important even than these achievements is the task of solving the problems of the future era. Giant sea walls will be built to protect New York's huge harbor. Answers will be found to the problems of smog and water pollution. Housing problems will be solved by building taller apartment buildings. Children will grow up better, due to this better housing and also to the increasingly superior nutrition they obtain. In the future facilities will be provided to guarantee more and better education to all those who can use it.

It is true that New York's future is only a dream, a whisper in man's mind, but by turning these dreams into reality, New York in the future will become a better city.

NEW YORK CITY, 2000

The year is 2000. Fifth Avenue isn't the same as it used to be forty years ago. The Empire State Building, one of the smallest buildings in New York City is still the one hundred and two stories that used to be so tremendous. One can't see the top of some of the taller buildings. There must be hundreds of cars on the new twelve-lane highways. The pedestrians take a footbridge over the crowded streets in order to cross.

During the day it gets very hot on the streets of New York in the summer, but every building is centrally air conditioned. On the streets you never see the sun, unless its directly overhead, because the tall skyscrapers form a non-ending wall on either side of you. Not only do the buildings extend up, but there isn't one that doesn't have at least twenty-five stories underground, where they have every type of store you could imagine.

All along Broadway there are television studios. The new televisions have fifty channels. At any hour of the day they have just about every type of program. There are movies on channels one through ten. Eleven through fifteen; sports. Sixteen to twenty; children's shows. Twenty-one to thirty; quiz games and variety. Thirty-one to thirty-five; news and weather. Thirty-six to fifty; opera, ballet, and concerts. All the programs are in living color. Since 1970 black and white television sets have been off the market.

With picture-phones you can now call anywhere on this earth and be able to see and talk with your party at a price no higher than it used to cost to call the same distance forty years ago. But you are still charged for overcalls (that's why A.T. & T. is still a good investment).

When a child is three he goes to one of New York's most modern elementary schoold until the seventh grade. Then to high school from eighth to fourteenth grade. After graduating high school, he may

go on to college (there are so many more now) where he may choose to study from any of the three hundred professions or vocations that haven't been taken over by automation. The average man works from 10:00 a.m. to 3:00 p.m. with an hour off for lunch. Most of the workers have a higher standard of living compared to the citizens of other countries, and more leisure time for himself and his family. At the age of forty-five he may retire with full social security benefits.

Hundreds of boats dock at the Hudson and East Rivers every day. They bring the exports from countries all over the world, and return with goods that were manufactured in the modern New York City factories. The products aren't touched by human hands until they get to the consumer. At the factories the products are made and packaged by machines. They are taken by truck, train, or monorail to the harbor where they are loaded onto the boats by cranes. The modern ships don't need tugboats to tow them out of shallow harbors.

Doctors have now found cures for every disease known to man. If there is anything wrong with any body organ, surgeons in the most modern hospitals can replace it with an artificial one that comes with a hundred year guarantee. The average lifetime is now about two hundred years.

There is no need to worry about producing enough food for the population because now the food factories in New York City can produce more artificial food in one day than a fifty acre farm with modern machinery could produce in one year. This artificial food is cheaper, but it tastes just as good as the real thing. If it wasn't for the label on the package you couldn't tell that it wasn't grown in the soil. The artificial food can last indefinitely without refrigeration, which is more than you can say for the food products grown on farms. Now the old

farm lands are turned into big industrial cities.

Once again people are flocking to the World's Fair and stare in awe at the wonders of things to come in the years beyond 2000.

**Silicon City:
Computer History Made in
New York
CLASSROOM MATERIALS
FOR THE EXHIBITION**

SILICON CITY

NEW-YORK
HISTORICAL
SOCIETY
MUSEUM & LIBRARY
MAKING HISTORY MATTER



NICK VAN WIGGEREN *Software Engineer, DigitalOcean*
Most of the day, I sit at a computer and write code. I work with about 20 software engineers in a big open space office with a couch in the middle. We're good friends. *We get stuff done but we have fun.*



YI JIAO *Designer, Level Solar*
My company designs and installs solar panels for houses. I do the blueprints and serve as tech support to the team. *I grew up in Shanghai*, which people call "Asian New York." I wanted to come here because it's like home.



KATHRYN WYLYDE *President & CEO, Partnership for New York City*
New York is a city for this generation of the Internet, *the application generation*. We are not the chipmakers, but we are able to apply technology in ways I think no other city can.



CHARLES E. PHILLIPS *CEO, InfoFor*
Half of our management team are women. Three of those are immigrants. We recruit the other ninety-nine percent from schools that aren't Ivy Leagues. *We're changing the face of technology*, at least attempting to.



SALONEE BHAMAN *Media Insight Specialist, Dropbox*
A lot of bias is subtle. Women are assumed to be better at certain things, like sales, than at others, like tech. You have to become an advocate for yourself, and believe you're entitled to what you want. *Why shouldn't it be me?*

SARAH OLIMPIA SCOTT *Software Engineer, Artsy*

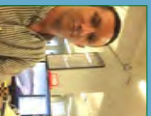
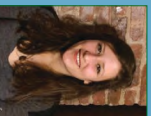
I'm on a team that makes iOS apps that galleries use to show their work. *I'm trained as an electrical engineer but I've always loved art*. I couldn't work at a job that was only tech.

MARCO VITI *Ad Campaign Analyst, Rubicon Projects*
I work with ad agencies to find the right place for ads to appear online, on mobile devices, or on videos. This field wasn't around 5 years ago. Now it's a *big business in New York* because the ad agencies are here.

CHAD DICKERSON *CEO, Esxy*
Young engineers and designers want to work in a place with entertainment and culture and good food. *New York is head and shoulders above* any other place in the world to build a tech company.

DAWN BARBER *Co-Founder, New York Tech Meetup*
New York Tech Meetup started as a place for people to get together and demo what they were working on. We've stuck to that format. *Show something cool*. Show something new and exciting in tech.

JANAN RAJEEV KARAN *Product Manager, Google*
I first experimented with building computers at age 15. At age 21, I bought a book on how to build iPhone apps and built my first app in a month. My advice for kids interested in technology is to *start tinkering. You'll learn a lot*.



AT&T is proud to support the Silicon City classroom curriculum and highlight the stories of pioneering women throughout the year. We are a part of the company's longstanding commitment to supporting STEM education.

An view of Manhattan looking North, 1962. The New-York Historical Society. Personal photographs courtesy of Dawn Barber, Salonee Bhaman, Chad Dickerson, Yi Jiao, Charles E. Phillips, Janan Rajeev Karan, Sarah Olimpia Scott, Marco Viti, Kathryn Wylyde, and Kathryn Wylyde.

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