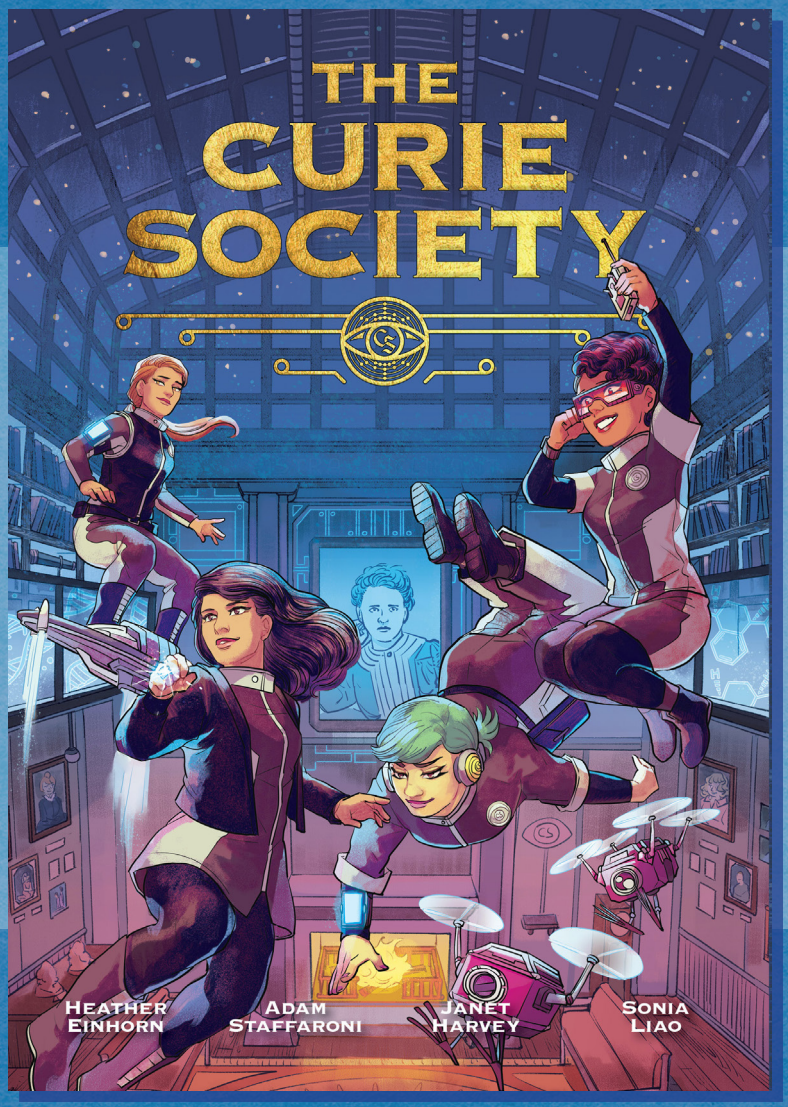
The Curie Society Educator Guide



This is meant to be used alongside *The Curie Society* graphic novel as a guide for educators and learners who are interested in diving deeper into STEM and Language Arts concepts within the book. You can order the book from MIT Press by visiting mitpress.mit.edu/curiesociety. You can ask us questions directly by finding us on Twitter @thecuriesociety, or by visiting our website thecuriesociety.com.

This guide was created by educators Dr. Joy Barnes-Johnson, Evelyn Rebollar, and Rebecca Brewer, together with Nadja Oertelt at Massive Science.

English & Language Arts Guide

Pre-reading Activities

Common Core Standards

While not all districts follow the Common Core State Standards, here are some details on Common Core alignment in districts where it is applicable.

9-10SL4: Present claims, findings, and supporting evidence clearly, concisely, and logically; organization, development, substance, and style are appropriate to task, purpose, and audience.

11-12SL1b: Work with peers to set norms for collegial discussions and decision-making, establish clear goals, deadlines, and individual roles as needed

11-12SL1C: Pose and respond to questions that probe reasoning and evidence; address a full range of positions; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives

11-12SL1d: Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task

The Curie Society empowers historically underserved students not only to take their seats at the STEM table, but also to find and use their voices in situations that would otherwise stifle them. Through analysis of character arcs and the human experience, educators can build a bridge between the privileged and the underserved so that the privileged understand the minority voice as an asset rather than a threat, and those who have been silenced or historically barred from STEM feel welcome and comfortable in their fields. As these discussions will, no doubt, be considered controversial for some and may trigger strong emotions in others, educators will want to create spaces in which students feel both comfortable to share opinions and safe to learn and explore new perspectives and ways of existing.

Before reading with students, set classroom or group agreements. That is, have them offer what they need from the group to feel like they are being respected, heard and challenged. Record contributions and begin each discussion by asking students to which agreement they will commit on that particular day **(CCSS 11-12SL1b)**.

Pre-Reading Activity #1: Discussion on Belonging (CCSS 11-12SL1c):

Have students list all parts of their identity or complete an identity chart (e.g., race, gender, religion, interests, hobbies, personality traits, birth order, etc.). Then ask them to share about a time when they felt ostracized from a group or felt like an outsider within a group. How did it make them feel? Which parts of their identity do they think the group lost by not including them? If they are stuck, encourage their peers to provide input on what the group specifically may have lost. Encourage them to share how this incident may have affected how they

currently approach situations in which they are new to a group. Continue by asking students under which circumstances might it be appropriate to exclude certain people from a group. What does the group lose and gain by the exclusion? What does the excluded party lose and gain by the exclusion?

Pre-Reading Activity #2: Jigsaw on Content (9-10SL4):

Label tables or different sheets of poster paper around the room with one of the following pairings of scientists and their field contributions:

Lamarr	Curie	Herschel	Wu	Jackson	Dresselhaus
GPS & Bluetooth	Chemotherapy	Comets	Nuclear Bomb	Space Exploration	Batteries

Ask students to walk to the table or poster with the scientific term or invention that piques their interest the most. Once students have formed their small groups based on their chosen pairs, provide each group with different sources highlighting its respective scientist and their contributions to their fields. Provide guidelines with which each group must present their chosen scientist to the larger group for note-taking, having them highlight what about the figure, field of study or invention is remarkable to them.

Research links for this activity:

- Hedy Lamarr: massivesci.com/articles/hedy-lamarr-inventor-world-war-movie-star-frequency/
- Marie Curie: massivesci.com/articles/marie-curie-science-hero-chemistry-nobel/
- Caroline Herschel: space.com/17439-caroline-herschel.html
- Chien-Shiung Wu: massivesci.com/articles/meet-the-first-lady-of-physics-queen-of-nuclear-research-and-destroyer-of-natural-laws/
- Mary Jackson: nasa.gov/press-release/nasa-names-headquarters-after-hidden-figure-mary-w-jackson
- Mildred Dresselhaus: massivesci.com/articles/3-incredible-stories-from-the-life-of-nanoscience-pioneer-mildred-dresselhaus/

Pre-Reading Activity #3: Discussion on Social Constructs:

Part 1 (CCSS 11-12SL1c):
Referring back to the identity lists or maps that students created for the first discussion, ask them to identify one part of their identity that they would be comfortable discussing in the group. Have them list all the expectations associated with the one they chose. Then, as a group, discuss from where these expectations for each identity come. Who enforces them? What purposes do these expectations serve? Who might benefit from students fulfilling these expectations? Who might be harmed or hurt by the expectations? How comfortable are students fulfilling these expectations?

Part 2 (CCSS 11-12SL1d):
After discussing, guide students in defining what a social construct is, and identify some of the social constructs depicted in *The Curie Society*. Assign different parts of the various characters'

identities to small groups of students and ask them to predict what struggles or social constructs they might expect the characters to face in the graphic novel. Allow small groups to share their predictions through discussion with the larger group.

Activities for Students During Reading

Common Core Standards

9-10R2: Determine one or more themes or central ideas in a text and analyze its development, including how it emerges and is shaped and refined by specific details; objectively and accurately summarize a text.

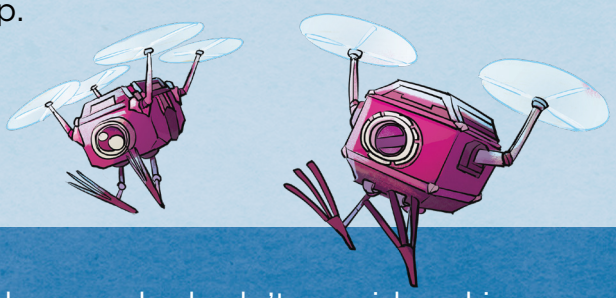
9-10R4: Determine the meaning of words and phrases as they are used in a text, including figurative and connotative meanings. Analyze the impact of specific word choices on meaning, tone, and mood. Examine technical or key terms and how language differs across genres.

9-10L3: Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.

9-10W2A: Introduce and organize complex ideas, concepts, and information to make important connections and distinctions.

9-10W3B: Use narrative techniques, such as dialogue, pacing, description, reflection, and plot line(s) to develop experiences, events, and/or characters.

11-12R3: In literary texts, analyze the impact of the author's choices. In informational texts, analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop.



Motif and Theme (CCSS 9-10R2):

Early in the students' reading, begin tracking motifs like failure, education, teamwork or romantic relationships by having students identify similar issues using different panels. As students continue reading, start each session by having them fill in empty dialogue/thought bubbles on poster charts around the room with examples from the text that show the motif. End the unit with students individually identifying the motifs that are most important to their personal lives. Why is the motif so important to them? Where do they see themselves represented within the motifs? What new perspectives about the motifs has *The Curie Society* offered that they maybe hadn't considered in the past? What personal perspectives about the motifs has *The Curie Society* challenged or solidified for them as individuals? Once students have thoroughly explored and expanded the motifs into themes, they can synthesize their claims in writing by creating original social media-style inspirational quotes and by using the examples on the poster paper as evidence to prove their claims.

Connotation vs. Denotation (CCSS 9-10R4, 11-12R3):

Project or print panels from pages 16, 31, 34, 81, 101 and 120 that show examples of connotation. Ask students to replace the dialogue bubbles with the literal meaning of the words spoken by each character.

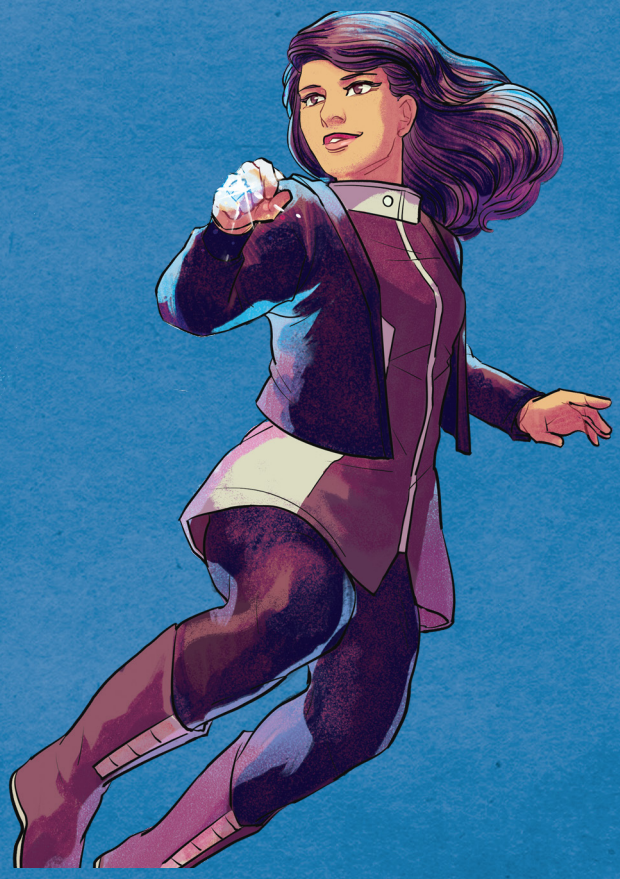
Then have students replace the dialogue bubbles with the intended message of the words spoken by each character. After a share out, use student interpretations to engage students in a discussion about connotation and denotation. How do tone, diction and context affect the connotative meaning of one's words? In what ways does connotation affect how characters relate or respond to one another in each of the panels provided? What were the author's reasons for using the given example of connotation? What is the utility of connotation in interpersonal relationships in general?

Conflict Resolution:

Part 1 (CCSS 9-10L3): Upon engaging students in the "Connotation vs. Denotation" discussion, they will have identified that connotation can sometimes perpetuate hostility. Ask participants to write the dialogue of a time when they had a conflict with someone else or of a conflict they witnessed in the past. Then have them note in their dialogue at what point the conversation turned into conflict. What was said or done to make the conversation go from dialogue to bickering? What was the tone of the line spoken that turned the conversation into a conflict? What could have been said or done differently to avoid the conflict, yet still meet all participants' needs? After asking participants to share their analyses of their dialogues, create a list with the group of both risk factors that contribute to conflict as well as actions or language that deescalate conflict.

Part 2 (CCSS 9-10W3B): Assign or allow small groups to choose from different points in the text in which verbal conflicts occur (pp. 9, 21-23, 33-36, 53-54, 78, 81, 91-92, 101, 114, 118-139 where multiple interpersonal conflicts occur at once) for analysis. Have each group identify which of the risk factors their interaction depicts. Then prompt groups to rewrite the dialogue so that the characters reach a resolution, and also to either draw or mark up the panels to show actions or mannerisms the characters could have changed to have avoided a conflict.

Part 3 (CCSS 9-10W2A): After small groups share their modifications with the larger one, either engage the whole group in discussion or assign an assessment. When is conflict necessary or good? What can people learn from engaging in it? In which situations might conflict be inevitable? What are the main factors that influence the extent to which a conflict persists beyond a single interaction between two people? What are the best ways to avoid a conflict lasting longer than a single interaction?



Colorfastness: From fast fashion to food—what's the problem?

"hot water sets stains" (pp 21 - 25)

Hands-on activity | Standards:

2-PS2-1: Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

5-PS1-3: Make observations and measurements to identify materials based on their properties.

MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

HS-PS3-4: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Overview: The clash between Maya, Taj and Simone in the early part of the story is a terrifically technical tale of dye! Learning about dyes means that you are learning about the chemistry of solubility, solutions and absorption.

Key concepts: solute, solvent, solubility, homogeneous/heterogeneous mixture, chromatography

JEDI Principles: Connecting Science, History and Social Justice

Whether a person dyes their hair, fabric for clothes or their food to turn a vanilla icing the perfect shade of green, coloring agents are important parts of our daily lives. As consumers, most of us may not think about where our food, clothes and textiles come from or how they are manufactured. We typically don't think about who makes them or how they are made, either. We often care most about how things taste, smell, feel and maybe look. The molecules that make up the dyes and coloring in our food, clothes and other goods can be natural products, like indigo or annatto, or synthetic — made in a lab environment. In both cases, studying these substances is the work of a chemist and has a unique history tied to industry.

Issue #1: In the fashion industry, designers and consumers alike are worried about a trend in fashion known as fast fashion and its impact on the environment. Read the story at earth.org/fast-fashions-detrimental-effect-on-the-environment/; brainstorm a list of problems and discuss potential solutions.

Issue #2: If we were to check the labels on most products we use or wear, we would find that they are made in developing nations. After flooding rains in a community in Indonesia, red-dyed flood waters were traced to a village dye plant. Read the story at bbc.com/news/world-asia-55966175; brainstorm a list of problems and discuss potential solutions.

Issue #3: Food allergies are very common. Read about food coloring allergies at nyallergy.com/food-coloring-allergy/; brainstorm a list of problems and discuss potential solutions. (Poll members of your community for any specific food-related or food dye allergies and how they solve this problem in their everyday lives).

Career Perspectives

Analytical chemists combine mathematics and computational knowledge and skills with questions. By studying all kinds of substances, analytical chemists can be found in any industrial field that gathers information about compounds. In this story, Simone's concern about toxicity to ants, Maya's laundry concerns and Taj's hair dying goals were probably all experiments done by analytical chemists at some point.

Hands-on activity (Formal/School; Informal/Out-of-school)

Science activities that explore dyes can be done safely at home, in school or in an out-of-school setting with everyday materials like paper towels, facial tissues, old t-shirts, water soluble (washable) markers and/or food coloring, water, club soda, rubbing alcohol* and clear containers.

Do Now/Warmup for all grades: *What do you notice about these samples? What do you wonder? How do the key concepts apply to this image?*

Elementary	Middle School	High School
Absorbance and materials 1. Paper and fabric 2. Tie dye tissue art (protocol online)	Separation of mixtures 1. Lemon tea: Physical vs. chemical changes 2. Chromatography (protocol online)	Solubility of dyes 1. By temperature 2. By polarity
Add drops of food coloring or washable markers onto various types of paper; use a spray bottle or pipette to add small amounts of water to the dyed paper. Observe what happens. Change the type of paper (or fabric) to see if the dyes behave the same way.	Understanding the difference between chemical and physical changes when it comes to dyes is a BIG IDEA. Add food coloring to club soda and water. Compare them. Make a cup of tea (brewed) in hot vs. cold water. Describe that process and compare to your "soda" mixes. Add lemon juice to your samples. What happens then? Decide if any of these "mixes" were changed chemically.	At the high school level, there are many different kinds of experiments that students could do to explore solubility. Invite students to design their own investigations based on those described for younger students.

**Rubbing alcohol experiments require adult supervision and/or are best done as a demonstration*

Looking for More Resources?

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, (September, 2020). Chemists and Materials Scientists, bls.gov/ooh/life-physical-and-social-science/chemists-and-materials-scientists.htm

Laundry challenges! (Tie to the story) maytag.com/blog/washers-and-dryers/choosing-hot-or-cold-water-for-stains.html

CRISPR, Bioethics and Genetic Engineering

"With CRISPR injections, we can design workers that are optimized for low-temperature environments." (pp. 121)

Hands-on activity | Standards:

MS-LS4-5: Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Overview: CRISPR-Cas9 technology is a tool to precisely cut and edit DNA sequences, modifying gene expression. It has the therapeutic potential to correct genetic defects and cure diseases, but it has also raised ethical concerns and prompted an international call for regulation and guidelines.

Should CRISPR be used to alter human germline cells and embryos? Who decides which traits to edit or enhance? Will accessibility to CRISPR gene therapy further marginalize society? If gene editing becomes widespread, will society be less accepting of those who are different?

Key concepts: CRISPR, gene-editing, protein, DNA, genome, mutations

JEDI Principles: Connecting Science, History & Social Justice

In February 2020, a renowned evolutionary biologist posted on social media, *"It's one thing to deplore eugenics on ideological, political, moral grounds. It's quite another to conclude that it wouldn't work in practice. Of course it would. It works for cows, horses, pigs, dogs & roses. Why on earth wouldn't it work for humans? Facts ignore ideology."* -Richard Dawkins

This controversial post elicited a strong reaction, mostly in opposition to Dawkins' musings. Eugenics translates to "good creation," and though the term was first introduced by British scholar Francis Galton in 1883, the practice has gone on since antiquity, with Greek and Roman societies eliminating those deemed unfit. On the darkest side, Nazis used eugenics to eliminate people thought to be inferior.

The historical roots of eugenics and CRISPR technology contain parallels: they both seek to enhance desirable characteristics. As science races forward, the ethical, legal and social implications of gene-editing tools are more closely monitored, criminalizing rogue scientists who misuse this tool. Today, the emphasis rests on reducing suffering with CRISPR over improving upon humankind.

Career Perspectives

Geneticists who specialize in ethics consider the legal, social and policy implications of genomics tied to research and patient care. By synthesizing knowledge from the biological sciences and health services sector, geneticists who focus on ethics oversee a broad spectrum of controversial issues associated with research and healthcare.

Interested in learning more about the bioethics of gene editing? Follow geneticist-ethicist @kstsosie on Twitter!

Learn more about her path to becoming a researcher: pbs.org/wgbh/nova/article/bioethics-crispr-indigenous-genome/

Hands-on activity (Formal/School; Informal/Out-of-school)

Want to build your own CRISPR-Cas9 paper model? Visit HHMI BioInteractive: biointeractive.org/classroom-resources/building-paper-model-crispr-cas9

Looking for More Resources?

Explore videos and classroom activities featuring the historical biography of genetic enhancement and ethical challenges: dptv.pbslearningmedia.org/collection/kenburnsclassroom/film/the-gene/

Conservation, Ecology and Wolves in North America

"Do you know about the wolves in Yellowstone Park? They had died out, but their reintroduction created a cascade of changes." (pp. 72)

Hands-on activity | Standards

2-LS4-1: Make observations of plants and animals to compare the diversity of life in different habitats.

3-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

HS-LS2-6: Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Overview: In 1926, the last gray wolf pack was killed in Yellowstone. Without this keystone species, the deer and elk populations pushed the limits of Yellowstone's carrying capacity as they overbrowsed willow, aspen and cottonwood trees. This in turn, impacted beaver populations, which need saplings to survive through winter. With fewer beaver dams, rivers flowed faster, reducing the quality of habitats for birds, amphibians and other animals.

Rewilding of wolves occurred in 1995, restoring North America's dominant predator to Yellowstone. Their presence decreased the elk and deer herds, increased the number of beavers and slowed the flow of rivers, transforming Yellowstone's ecosystem.

What role do wolves play in a trophic cascade? What led to the extermination of wolves in Yellowstone? How have wolves been historically represented in different cultures?

Key concepts: extinction, reintroduction, trophic cascade, ecosystem, predator-prey interactions

JEDI Principles: Connecting Science, History & Social Justice

For centuries, indigenous peoples have revered wolves in art and stories as benevolent spirits. In contrast, Western preconceptions about the nature of wolves — from untamed to bloodthirsty killers — guided past actions. Some estimate there were as many as two million wolves inhabiting the continental United States before European colonization.

Westward expansion in the 1800s brought settlers, agriculture and livestock in contact with native species. Wolves preyed upon

domestic stock, igniting a nationwide bounty. This dark history was supported by the federal government, which incentivized unregulated hunting and poisoning, deliberately driving wolves to the brink of extinction.

In 1974, the Endangered Species Act sought to protect the gray wolf, and today, their population in the contiguous United States numbers more than 6,000 individuals.

Career Perspectives

Conservationists are stewards for the natural world who seek to protect wildlife. As environmental advocates, conservationists promote public awareness and educate policy makers on ecological issues, while developing strategies for resource management and sustainability practices.

Interested in learning more about wolf conservation? Follow @NWCWolfwatcher on Twitter!

Learn more about one scientist's path to becoming a wolf researcher: missoulian.com/news/state-and-regional/montanas-diane-boyd-the-jane-goodall-of-wolves/article_1279cdee-40e8-51eb-af4c-543f9d718132.html

Hands-on activity (Formal/School; Informal/Out-of-school)

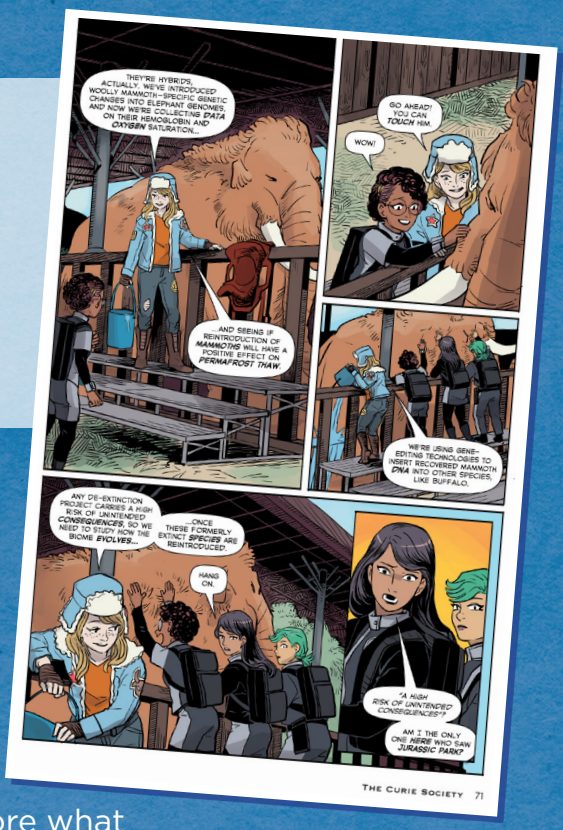
Want to model trophic cascades using organism cards from different habitats? Visit HHMI BioInteractive: biointeractive.org/classroom-resources/modeling-trophic-cascades

Looking for More Resources?

Watch a video about wolf reintroduction and construct a Yellowstone food web: serendipstudio.org/sci_edu/waldron/?fbclid=IwAR2ZSMKNl7L0cNfdJTXP97Ieh4eEJDsAAMpGIGGNU8s-8wKgVIwUbNIfaN8#foodweb

De-extinction & Permafrost

"We are using gene editing technologies to insert recovered mammoth DNA into other species like buffalo...any de-extinction project carries a high risk of unintended consequences, so we need to study how the biome evolves...once these formerly extinct species are reintroduced." (pp. 71-72)



Hands-on activity | Standards

HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. (HS/MS)

3-LS2-1: Construct an argument that some animals form groups that help members survive. (ES)

Overview: Imagine these questions: How might a herd of grazing "recovered" mammoth reconfigure food webs? How possible is it to recover and bioengineer genetic material from extinct or decomposing material found as a result of glacial melt? On their trip up to Waterton-Glacier International Peace Park, Simone, Maya and Taj explore glacial environments and are introduced to a top secret de-extinction project. The idea is a provocative one that is being tied to glacial melt. This activity is designed to explore what happens to live and synthetic materials when subjected to ice, thawing, and excavation. *Fun fact: Time Magazine's 2020 Kid of the Year, Gitanjali Rao recently said in a recent interview if anyone figures out how to bring dinosaurs back to life, give her a call!

Key concepts: permafrost, biome, tundra, glacial melt, sea level rise

JEDI Principles: Connecting Science, History & Social Justice

When the headline "Anthrax strikes Siberia for the first time since 1941" first appeared in the news in 2016, the science-meets-fiction world was set ablaze! The possibility of a "Jurassic park" style de-extinction of species that lay dormant for sixty-five years being awakened by climate change outcomes still seems incredible. Researchers exploring the possibility of de-extinction must also consider a full range of consequences for experimentation in this area, such as the geopolitical consequences of environments transformed by outbreaks and changing ecologies as well as the scientific implications for new appearances of old viral nemeses.

Issue #1: Glacial melt contributes significantly to sea level rise. Because the planet is dynamic and there is only one ocean, as glaciers melt in places like Alaska, water flows toward land. When coupled with extreme temperature shifts, weather can be unpredictable and many cities are not storm-ready. Read about sea level rise at sealevel.nasa.gov/understanding-sea-level/global-sea-level/ice-melt; brainstorm a list of problems and discuss potential solutions.

Issue #2: Ever since live anthrax spread was discovered in Siberia, a tundra ecosystem, there has been a growing concern that glacial melt will thaw and awaken dormant diseases in decomposing organic matter. Read the story at bbc.com/earth/story/20170504-there-are-diseases-hidden-in-ice-and-they-are-waking-up; brainstorm a list of problems and discuss potential solutions.

Issue #3: Green burials are a way to restore nutrients to overgrazed soil. Many large mammals are buried by nature when they die. Farming industries also regularly compost livestock (also called animal mortality composting). Increasingly, humans who see themselves as part of nutrient cycling on earth want to be made into compost and used to enrich the earth too. Read the story at sciencenews.org/article/green-burial-environmentalism-cemetery-eco-friendly-death; brainstorm a list of problems and discuss potential solutions.

Career Perspectives

Science Photographers capture natural, medical and technical images in a variety of settings. Because they have both technical knowledge of scientific subjects and artistic understanding, science photographers help communicate science to the public.

Hands-on activity (Formal/School; Informal/Out-of-school)

Science activities that explore what happens when things buried in ice are thawed are an interesting way to approach the idea of permafrost.

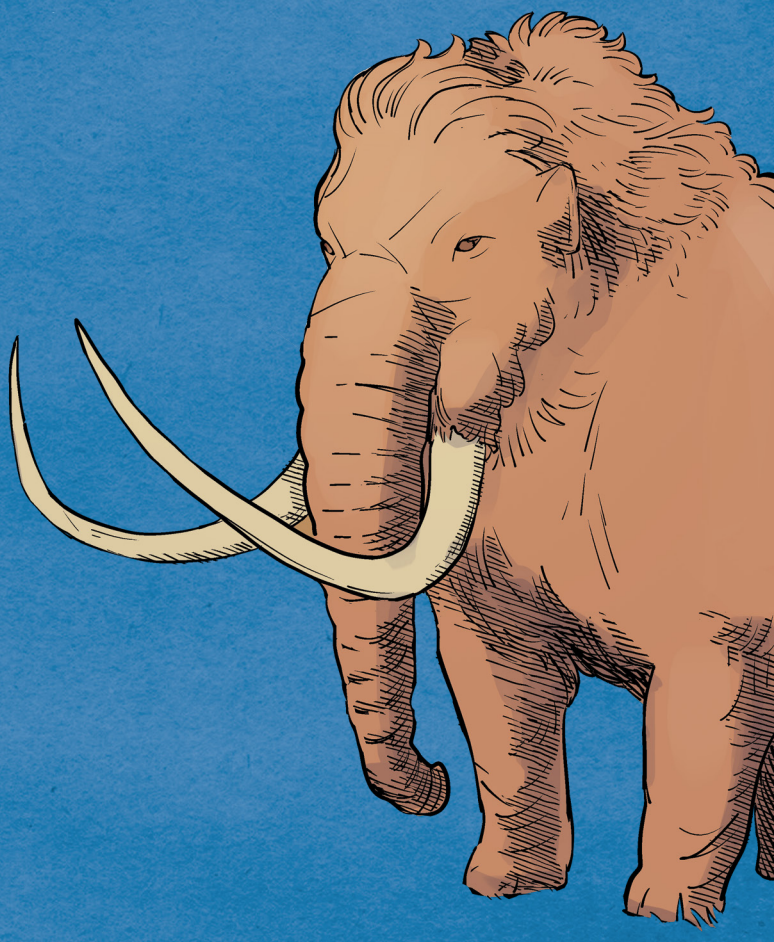
Do Now/Warmup for all grades: *Explore the impact of climate change using a Google Earth map. What do you notice about the various locations on the "tour"? What do you wonder? How do the key concepts listed previously apply?*

Elementary	Middle School/High School
Young children can explain the differences between living and nonliving things before and after the thawings.	Older children can begin to make sense of biotic and abiotic factors that influence thawing, connecting information from independent research, the Google Earth visualizations and their own models. Invite older students to write up and conduct additional modeling experiments by changing the concentration of salt in the ice melt, measuring how much time it takes for a certain mass or volume of water to melt during each thaw event, or some other variable they choose to investigate.
All grades will do the same activity: Gather small objects (e.g. fresh, dried or decaying fruit/food, leaves, twigs, hard plastic bottle caps, paper clips), styrofoam cups, salt, sand and soil. Design an environment that is layered with soil/sand first with scattered objects on the surface to a level about ⅓ the height of the cup. Mix salt and water before pouring it into the styrofoam cup. Freeze the cup for at least a week before thawing it. Allow it to thaw partially and peel off the cup, observe your "glacier" then refreeze it with a new cup. Repeat a few times before allowing it to completely thaw. Take pictures at each "thawing" as data. Write up your observations.	

Looking for More Resources?

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, Photographers at bls.gov/ooh/media-and-communication/photographers.htm

Explained: Alaska snow melt over time svs.gsfc.nasa.gov/13492



Prosthetics

"What does it mean to be human? Often when we talk about being human, it's within the context of our limitations: age, mortality, physical disability." (p. 113)

Hands-on activity | Standards

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost; 3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. (ES)

MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Overview: Xio & Jo have a complex history characterized by internal personal and political wars: entangled in our designed world, both scientists seem to grapple with thinking about what we label as valuable, disposable, useful and not. As scientists and engineers, they are also grappling with how to strike a balance between work for human good and capital gain. The characters and former friends are on opposite sides of these ideas. Sustainable Development Goal (SDG) #9 is a call for all citizens to imagine the relationship between "Industry, Innovation and Infrastructure", perhaps for the greater human good, not just certain human goods.

Key concepts: Sustainable development goals (SDGs), universal design

JEDI Principles: Connecting Science, History & Social Justice

At the beginning of the century, many global organizations sought to understand how to meet the world's needs for environmental, political and economic stability. The needs of nations big and small, developing and developed, are universally tied to the human condition. Who we are and what it means to be human is more than what we can do and who we are (what we look like). Human choices often lead to social dilemmas that can only be resolved through creative solutions and the use of our imaginations. Over time, the millennial goals outlined by the United Nations conference became a list of 17 sustainable development goals that are guideposts for us all to reach. All seventeen goals are important and yet very few people know they exist as a set of critical change ideas. Use the goals and related global resources to educate people and design challenges (short-term or long-term) for individuals or groups.

Start learning by sorting the SDGs into categories to create teams for group work, or as an organizing framework for individuals. Determine which should be categorized as political, economic, environmental or other. Identify goals as a learning target for the year.

Issue #1: (Political) A global perception of risk is a uniquely political and complex challenge to consider. There are so many indices for risk that can be considered. Analyze data that capture these complex ideas at reports.weforum.org/global-risks-report-2021/survey-results/; brainstorm a list of problems and discuss potential solutions.

Issue #2: (Economic) Our world is heavily designed, whether we are aware of it or not. Our clothes, technology and our preferences are largely predetermined because of the way clothes are used and made to function. Read (or listen to) the story at the1a.org/series/designing-our-world/; brainstorm a list of problems and discuss potential solutions.

Issue #3: (Other) Able-bodied people rarely recognize when a space or resource is not accessible. Neurotypical people may not recognize when a set of directions or a manual are unreadable. Read about a history of barrier smashing in the United States at americanhistory.si.edu/blog/smashing-barriers-access-disability-activism-and-curb-cuts; brainstorm a list of problems within your community related to accessibility and discuss potential design solutions.

Career Perspectives

Civil engineers focus on infrastructure and transportation designs. As cities age and people live longer, the kinds of systems used to keep people mobile will depend on the materials available to construct, repair and rebuild old structures.

Hands-on activity (Formal/School; Informal/Out-of-school)

School-based engineering activities are a little different than science activities because the end product is usually a prototype or model of a greater vision. While observations and questions may drive scientific experiments differently than they do for engineering projects, the science and engineering projects can often reduce the work and effort of the experimenter, improve efficiency in a process and/or reduce the amount of waste of materials.

Do Now/Warmup for all grades: *Watch the video about Gitanjoli Rao, 2020 Time Kid of the Year at* youtube.com/watch?v=f2RQMOft5w8.

What do you notice about how she connects her interests to how she hopes to see a world filled with kindness? What do you wonder? How do the key concepts apply?

Elementary	Middle School	High School
Universal designs require identical criteria: design a system to move a marble in an expected way with minimal effort on the part of a human. This task is called Becoming an A-MAZE-ing Marble Mover. Designing an automated maze for a marble that is a multidimensional maze/cardboard structure (more than just a straight line) and allows a marble to travel with low/no effort from a player is the goal. Work in teams to design, draw a model and write directions for construction. Try to capture the design tests with a video or photos.		
Design a maze from simple, recycled materials in teams based on specific patterns.	Design a maze from simple recycled materials in teams with a goal of creating a system that has low volume/mass specifications.	Design a maze from simple recycled materials in teams with a goal of creating a system that has low volume/mass specifications. Doing a cost benefit analysis for materials at scale imagining the marble as a wheelchair, what might a wheelchair ready ramp or maze system look like and be designed to do?

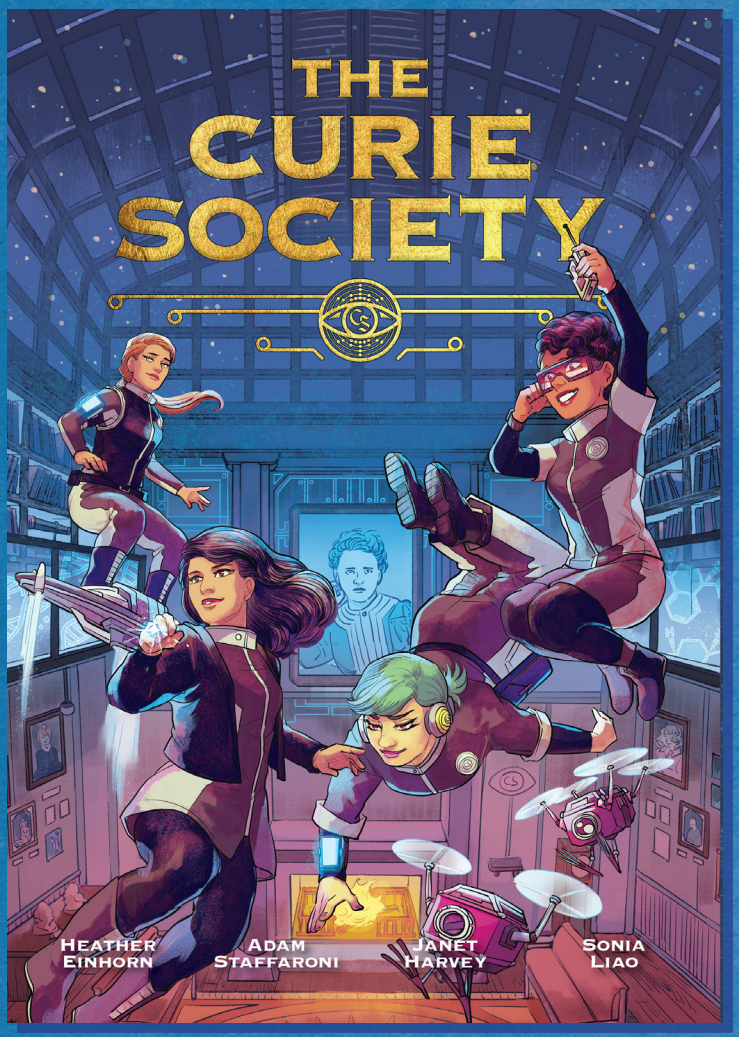
Looking for More Resources?

Seven principles of universal design: universaldesign.ie/what-is-universal-design/the-7-principles/the-7-principles.html

100 Women of Chemistry Infographic: compoundchem.com/women-in-chemistry/

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, Civil Engineers bls.gov/ooh/architecture-and-engineering/civil-engineers.htm

About the Book:



ISBN: 9780262539944
Also available as an ebook
mitpress.mit.edu/curiesociety

An action-adventure original graphic novel, *The Curie Society* follows a team of young women recruited by an elite secret society—originally founded by Marie Curie—with the mission of supporting the most brilliant female scientists in the world. The heroines of the Curie Society use their smarts, gumption, and cutting-edge technology to protect the world from rogue scientists with nefarious plans. Readers can follow recruits Simone, Taj, and Maya as they decipher secret codes, clone extinct animals, develop autonomous robots, and go on high-stakes missions.

The Curie Society introduces an entertaining, empowering media universe for fans hungry to read about brilliant, analytical young women as scientific heroes. Stay tuned for more Curie Society missions featuring our heroes saving the world through their STEM skills and teamwork.

Praise for the Book:

"Readers eager for greater representation of women in the sciences will cheer to this empowering if squeaky-clean spy adventure." – *Publisher's Weekly*

"The characterization is deft and snappy, and the visual storytelling efficient and dynamic. . . . A STEM treat for the curious." – *Kirkus Reviews*

"Budding scientists and fans of exciting graphic novels are in for a rollicking journey that stresses that women in STEM truly are better together." – *School Library Journal*

"With suspenseful espionage, nerdy humor and a group of dauntless, eager trailblazers fostering genuine friendships, *The Curie Society* is sure to fascinate curious minds." – *Shelf Awareness*

About the Book Creators:

Heather Einhorn, born and raised in New York City, grew up loving Teenage Mutant Ninja Turtles, Batgirl, female detective stories, and teen spy thrillers, and she co-founded EEP in order to create stories showcasing heroic women characters. With her husband and creative partner Adam Staffaroni, she co-created the popular scripted podcasts Daughters of DC and Lethal Lit: A Tig Torres Mystery, which was listed as a New York Times Great Podcast and was the first Young Adult scripted podcast.

Adam Staffaroni has been creating comics in one form or another for the past fifteen years. He received an MFA as part of the first-ever graduating class at The Center for Cartoon Studies. With Heather Einhorn, he co-created the scripted podcasts Daughters of DC and Lethal Lit: A Tig Torres Mystery.

Janet Harvey is an award-winning writer of comic books, movies, and games. Her works include the first full length adventure of Cassandra Cain, the graphic novel Angel City, and her first feature film, A Million Hits.

About the Educational Guidebook Creators:

Dr. Joy Barnes-Johnson teaches and consults for various STEM education projects in several states. Her research and writing interests examine training, policy and curriculum for equity in formal & informal settings. Recent projects include OpenSciEd, Project CHOOSE & local racial literacy programs.

Evelyn Rebollar is a national award-winning high school educator of ten years, serving students in the Soundview area of the Bronx, New York. Her work is featured in the National Council for Teachers of English, Chalkbeat, The Atlantic, and PBS Newshour.

Rebecca Brewer is a national award-winning biology educator in Michigan and the coauthor of Biology Now. She has developed resources for PBS NewsHour, Science Friday and MiniOne Systems and is a Teacher Ambassador for the National Center for Science Education.

Nadja Oertelt is a cofounder of Massive Science. She is a science media producer, documentary filmmaker and former research scientist.

Massive Science worked to ensure the STEM storylines in *The Curie Society* were accurate and educational. Massive Science is a content and media company that delivers science stories and reporting to general audiences. It is dedicated to helping scientists share stories about their work and lives in pursuit of a more informed, rational, and curious society.

For more educational information about women in science, please visit
massivesci.com/themes/our-heroes/

The MIT Press EEP MASSIVE SCIENCE