

IMAGINE

YOUR STEM FUTURE A GUIDE FOR VOLUNTEERS

A STEM career and leadership series for high school girls to be used with *GIRLtopia* or *BLISS: Live It! Give It! Journey* books



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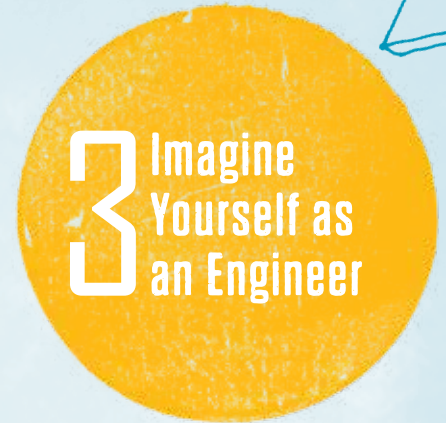
Girls notice the science in everyday stuff—like what’s in their backpacks. They’ll design a future product and then try their hand at computer programming (without a computer).

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Imagine Planner

Imagine Your STEM Future is designed as four units, each requiring 90 minutes or more. You can easily break out this series into eight sessions, 45 minutes each, this way:

UNIT 1: Session 1	Session 2
<ul style="list-style-type: none"> ● Opening Ceremony: Draw a Scientist ● Activity 1: Science in Your Bag ● Activity 2: Design the Future ● Have more time? Do Imagine More: Design and Create a Future City ● Closing Ceremony: Imagine Your Cutting Edge Career 	<ul style="list-style-type: none"> ● Opening Ceremony: "Why GIRLtopia?"; BLISS: "Your Wildest Dream!" ● Activity 3: Sort Yourself! ● Have more time? Do Imagine More: Quick Sort Cards ● Closing Ceremony: "Shared Visions of GIRLtopia"; BLISS: "Curtain of Dreams, Part 1"
UNIT 2: Session 1	Session 2
<ul style="list-style-type: none"> ● Opening Ceremony: Discovered in a Lab ● Activity 1: Cup Puzzle ● Activity 2: Extract DNA from a Banana ● Have more time? Do Imagine More: Extract Your Own DNA ● Closing Ceremony: Imagine a Career in a Lab 	<ul style="list-style-type: none"> ● Opening Ceremony: "What's Our Ideal Group?"; BLISS: "When Values Collide" ● Activity 3: Food Science Challenge ● Have more time? Do Imagine More: Test Gluten in Flour ● Closing Ceremony: "Envisioning GIRLtopia Through Art"; BLISS: "Curtain of Dreams, Part 2"
UNIT 3: Session 1	Session 2
<ul style="list-style-type: none"> ● Opening Ceremony: What Engineers Do ● Activity 1: Human Circuit ● Activity 2: Switch Hitter ● Have more time? Do Imagine More: Game Show ● Closing Ceremony: Imagine a Career in Engineering 	<ul style="list-style-type: none"> ● Opening Ceremony: "Girls' Bill of Rights"; "A Symbol of Bliss" ● Activity 3: Soft Circuit Textiles ● Have more time? Do Imagine More: Be a Fabric Tester ● Closing Ceremony: "'Create It' Time"; BLISS: "Dreams on a Wire"
UNIT 4: Session 1	Session 2
<ul style="list-style-type: none"> ● Opening Ceremony: What Environmental Scientists Do ● Activity 1: Electric Connection ● Activity 2: Oil Spill! ● Have more time? Do Imagine More: Sand Cleanup ● Closing Ceremony: Imagine a Career in Environmental Science 	<ul style="list-style-type: none"> ● Opening Ceremony: "Catch the Dreams"; BLISS: "Putting Passion Busters in Their Place" ● Activity 3: Heron's Fountain ● Have more time? Do Imagine More: Viscous Drag ● Series Closing Ceremony: Hand out Certificates of Completion; "Ode to a Leader"; BLISS: "Random Acts of Inspiration"

Welcome to Imagine Your STEM Future

Dear Volunteer,

READ THIS FIRST!

Careers in science, technology, engineering, and math (STEM) are growing at five times the rate of other occupations. By 2018, it's expected that nine of the 10 fastest-growing occupations will require significant science or math training. Our country needs more girls in these field, and we need them *now!*

Studies show that girls begin to lose confidence and interest in science and math during middle school. And they are often unaware of STEM careers and opportunities. But it's not too late for them to find out—even now at the high school level—and you can help! Here's how:

- By getting girls engaged in the hands-on girl-led activities in this program.
- By sharing the real-world examples of successful women engaged in STEM careers.

"Girls are more successful in math and science programs that incorporate a cooperative, hands-on approach than in programs that stress competition and individual learning."

—National Council for Research on Women

You don't need to have a background in any of the topics covered in *Imagine Your STEM Future* to run this series. Everything you need is included in this guide. You get to learn by doing, alongside the girls!

Let Girls Know...

Throughout *Imagine Your STEM Future*, we use the word *science* as shorthand for STEM fields of science, technology, engineering, and math. We use *scientist* for all the people who work in the fields.

IMPORTANT!

I. Getting Started: What You'll Use

Each girl should have her own *Imagine* booklet and *Journey* book.



Imagine Your STEM Future Volunteer Guide



Imagine Your STEM Future Girl Book



GIRLtopia (Girl Book and Adult Guide for 9th- and 10th-grade girls)



BLISS: Live It! Give It! (Girl Book and Adult Guide, for 11th- and 12th-grade girls)

2. What You'll Find in Each Unit

UNIT OVERVIEW A brief description of what's in each unit.

PREPARE AHEAD What to do in advance of the next unit.

OPENING AND CLOSING CEREMONIES To engage girls in the unit's theme and showcase careers and leadership ties.

LEADERSHIP CONNECTIONS Before you begin the series, take a look at the Adult and Girl Journey Books for *GIRLtopia* or *BLISS: Live It! Give It!*, depending on your group's grade levels. In each unit of *Imagine Your STEM Future*, you will find a Leadership Connection that ties to the Journey. You don't have to follow these tie-ins word for word; once you get a topic started, listen to where girls want to take it!

Make Leadership Connections

- S DO:** Activity on page 37 of your *GIRLtopia* Adult Guide “Do We Need GIRLtopia?”
- S ASK:** Girls to discuss Oprah Winfrey’s quote on page 37 of their *GIRLtopia* Girl Book.
- A DO:** Activity on page 29 of your *BLISS: Live It! Give It!* Guide “Opening Ceremony: Your Wildest Dream!”

MATERIALS LIST Most materials are household items or can be purchased at local supermarkets and hardware stores. You can also order some of the hard-to-find materials by calling **888-698-8463**.

THREE ACTIVITIES *Imagine Your STEM Future* Girl Book pages are reprinted here to show the step-by-step instructions alongside your Volunteer Instructions, which will help inform each step.

TWO IMAGINE MORE ACTIVITIES These activities are optional.

3. Keep It Girl Led!

Invite girls to decide which *Imagine More* activities they're interested in doing. You'll need to know in advance, to help you prepare materials for each session.

There's a lot more fun and information online to help you facilitate this series! Check out gsuniv.org/imaginefacilitators and forgirls.girlscouts.org/imagine.

Leadership, Journeys, and Imagine Your STEM Future

Imagine Your STEM Future might inspire girls to...

- Take an additional science or math class.
- Join a science club or sign up for summer camps or community programs with a focus on sciences.
- Mentor a younger girl in a science fair project.
- Become a volunteer at a science museum.
- Begin to research science scholarships.
- Seek out role models and mentors—such as a science or math teacher, a friend or relative working in technology or engineering, or a career counselor who can help guide her next steps.

National Leadership Journeys unite Girl Scouts across the country by inviting them to explore themes that help them become leaders who take action and change the world.

Although you will not be doing a whole Journey throughout the Imagine Your STEM Future series, we have made Leadership Connections throughout where you can ask girls to refer to their Journey books and find out how the science fun fits together.

Girl Scouts and Leadership

Play is serious business and at Girl Scouts, everything we do is designed for maximum fun. But behind the scenes, the activities we create help girls learn and grow—and provide them with what educators call problem-solving, critical-thinking, and conflict-resolution skills. While girls are simply having a good time, we know that the activities they are doing have a purpose. So how do we tap girls' curiosity and light up their imaginations?

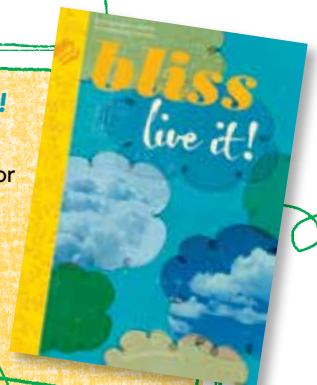
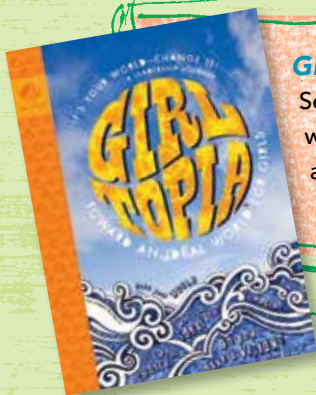
The Leadership Journey Themes

GIRLtopia

Seniors imagine a perfect world for girls. Leaders, after all, are visionaries!

BLISS: Live It! Give It!

Ambassadors see how dreaming big—now and for the future—opens doors to new adventures for themselves and others.



Here's the secret behind the Girl Scout Leadership Experience:

DISCOVER SELF We help girls develop a strong sense of self by discovering who they are and what they care about. They gain practical life skills and positive values that they will use for the rest of their lives.

CONNECT We encourage girls to connect with others, develop their people skills, and care about, inspire, and team with others, locally and globally.

TAKE ACTION We show girls how to take action to make the world a better place. They advocate for themselves and others, are resourceful problem solvers, and learn how to inspire others to act.

Everything you need to accomplish the Girl Scouts Leadership Experience is in the Imagine Your STEM Future series. You'll bring it to life for the girls—helping them to discover their dreams and passions, feel empowered to make a difference in the world, and pursue science careers that fulfill their goals. Of course, the magic, fun, and friendship of Girl Scouting happens not just in what girls do but also in how they do it. As you do the activities, keep these three ways of interacting with the girls in mind:

GIRL LED Let girls plan and make their own decisions. For example, invite girls to select activities they're interested in doing. Or teams they want to form. Or ideas they might have about how to open or close a session. Give girls the opportunity to feel ownership of this series so that it's even more fun.

LEARNING BY DOING Every activity the girls do involves being hands-on. We give you discussion ideas (called **ASK**) to guide girls to talk about what they experienced, so that they can apply what they learned now and in the future.

COOPERATIVE LEARNING Girls learn a lot when they work together toward shared goals in an atmosphere of respect and collaboration. While building their relationship skills, help the girls create a team that makes them feel safe and supported.

KEEP IT FUN! The activities in Imagine Your STEM Future are designed for hands-on, cooperative learning, and some involve team competition. Remind girls that there is nothing to prove! It's all about the fun of trying something new in science.

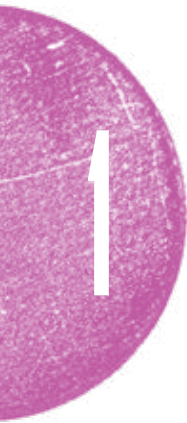
Look for These Symbols

S If you have 9th and 10th graders—Girl Scout Seniors—refer to the *GIRLtopia* Journey Girl Book and Adult Guide, and look for this symbol.

A If you have 11th and 12th graders—Girl Scout Ambassadors—refer to the *BLISS: Live It Give it!* Journey Girl Book and Adult Guide, and look for this symbol.

S A If your group includes both age groups, refer to both Journeys.

Imagine Yourself on the Cutting Edge



Unit 1 Overview

OPENING CEREMONY

Draw a Scientist What girls think a scientist looks like.

S "Why GIRLtopia?" Making science ties to global issues.

A "Your Wildest Dream!" Can a girl's future dream include science?

ACTIVITY 1: SCIENCE IN YOUR BAG Explore the science behind an item girls can't live without.

ACTIVITY 2: DESIGN A FUTURE PRODUCT Taking a familiar item into the future.

IMAGINE MORE: Girls create a future city.

ACTIVITY 3: SORT YOURSELF! Girls experiment with parallel processing—no computer involved.

IMAGINE MORE: Girls sort with playing cards.

CLOSING CEREMONY

Imagine You! Girls consider a cutting-edge career.

S "Shared Visions of GIRLtopia" How women in science make a difference.

A "Curtain of Dreams, Part 1" Girls contemplate and write their future dreams.

Prepare ahead

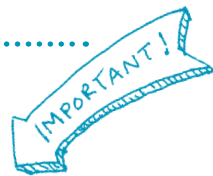
DOING TWO SESSIONS? The planner on page 3 shows you how.

OPENING CEREMONY "Your Wildest Dream!"—form a large piece of absorbent cotton into a cloud-like shape.

ACTIVITY 3: SORT YOURSELF! Use painter's tape or chalk to re-create the sorting network shown on page 16 of this guide. You can create more than one if you have the time and space.

CLOSING CEREMONY "Curtain of Dreams, Part 1"—cut paper of any kind (recycled) into at least 100 inch-wide strips.

OPENING CEREMONY



DO Introduce yourself! Let the girls know why you're excited to guide them through this experience.

DO Ask girls to draw a scientist. Tell them this exercise is about assumptions! After a minute or so, have girls share their sketches. Did girls sketch some variation of a man in a white lab coat?

If you were provided pre-session evaluation forms, now would be a good time to ask girls to complete and hand them in.

SAY *Researchers have found that women and men don't differ on math and science abilities. You are just as capable as a man of making the world a better place through science—and making a great salary too. Right now, there are more jobs than ever in science fields. The world needs you! Through Imagine, we hope you find that there's no limit to the future—for yourself and for the world.*

Make Leadership Connections

S DO Invite girls to look at "Why GIRLtopia?" (page 9 of GIRLtopia Girl Book). Get girls to talk about how scientists might play a part in these global issues and ways scientists could help create a GIRLtopia.

A DO "Your Wildest Dream!" (page 29 of BLISS Adult Guide). Ask girls if they have dreams about what science will do for their future or if they dream of science careers.

KEY } **S** Grades 9–10
A Grades 11–12

ACTIVITY 1: SCIENCE IN YOUR BAG

ACTIVITY GOAL To get girls to make connections between must-have items and the science behind them

TIME Approximately 10 minutes

STEP 1: SELECT AN ITEM

DO Have each girl select something from her purse or backpack that she couldn't live without—perhaps her phone, music player, or lip balm.

STEP 2: SHARE THE ITEM

SAY Scientists help improve our lives by solving common problems. Think about your item: How does it make your life better or easier? Introduce yourself and tell us your answer!

Sample responses "I use my cell phone most when I need a ride somewhere."

"My lip balm keeps my lips moist."

STEP 3: FIND THE SCIENCE

ASK Girls to imagine what kind of science and scientists might have contributed to their item:

How do you think your item started as a scientist's idea?

Sample responses "A scientist noticed people sometimes need to make calls when they're far from a landline."

"A scientist noticed dry, windy weather causes lips to chap and peel."

What kind of discovery might have contributed to your item?

Sample responses "The ability to transmit voices through cell towers."

"A soft and oily ingredient in a balm that keeps lips moist."



Unit 1 Materials

S GIRLtopia (Girl Book and Adult Guide)

A BLISS: Live It! Give It! (Girl Book and Adult Guide)

- Lab notebook and pen or pencil for each girl

OPENING CEREMONY: DRAW A SCIENTIST

- Colored markers, pens, or pencils; and paper

"YOUR WILDEST DREAM!"

- Cotton to make a cloud

IMAGINE MORE: DESIGN A FUTURE CITY

- Art supplies: glue or tape, paint, straws, toothpicks, construction paper
- Clay (optional)
- Everyday household objects: paper towel holders, milk cartons, plastic containers, foam cups, egg cartons, cans, bottles, toys

SORT YOURSELF!

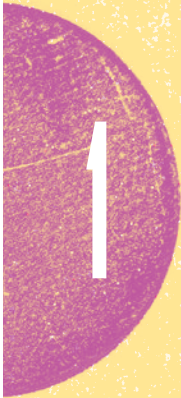
- 3 rolls of painter's tape or chalk
- Sticky notes
- 1 timer per team: cell phone, clock, watch, or kitchen timer
- 9' x 12' painter's drop cloths, 1 per diagram (optional)

IMAGINE MORE: QUICK SORT CARDS

- Playing cards: 1 deck per team of four girls

CLOSING CEREMONY CURTAIN OF DREAMS, PART 1

- Paper of any kind
- Scissors



Imagine Yourself on the Cutting Edge

DESIGN THE FUTURE

YOU ARE A PRODUCT DESIGNER. That means that when you look at all the items around you—from your phone to your bag to your chair—you're thinking about how they work and how they could work better.

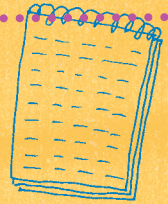
Design Brief

Improve an everyday product for the user of the future. Be as wild and creative as you want—who knows what the future will hold?

STEP 1: ASK THE BIG QUESTIONS

Materials

- Pen or pencil
- Paper (A lined, spiral notebook would be ideal to use for all your Imagine activities. Call it your lab notebook.)



NOW IN 10 YEARS



What is it?

Who uses it?

What does it do?

What could it do better?

Blank lined area for writing answers to the 'NOW' column questions.

Blank lined area for writing answers to the 'IN 10 YEARS' column questions.

Volunteer Instructions

ACTIVITY 2: DESIGN THE FUTURE

ACTIVITY GOAL To engage girls in the design process as they imagine future designs for items that matter to them

TIME Approximately 30 minutes

TEAMS Girls can work alone or with a partner

SAY *Most of the everyday objects around us started as the spark of an idea in a scientist's mind. Now you're the scientist—in this case, a product designer.*

SAY *You may have an image of a scientist as a loner who hides in a lab and avoids people. The truth is, scientists can be really social! They interact with fellow scientists and advisors. A big part of being a scientist is exchanging ideas—and criticisms. So in this activity you might want to work together as if you're in a product design lab.*

ASK

What is it? "It" depends on what you use the product for. Some people use their phone to surf the Web, others to text, and others to talk to relatives far away. "It" might not even be an object!

Who uses it? Which groups use this product, and what do they want from it?

Example, for a phone:

- **Consumer** Wants a low-cost way to communicate with friends. Bonus if the phone looks cool.
- **Manufacturer** Needs to make a profit, so prefers a product made of simple and cheap materials.
- **Society** Wants a "green" phone that has the least negative impact on the environment. What happens to old phones?


What does it do? What could it do better?

Product designers often use these brainstorm exercises:

- Pick up the item, start to use it, and jot down at least five things it does for you and five things you wish it could do.
- Observe someone using the product and jot down five ways she uses it. In what order does she do things? Where does she get stuck?



Volunteer Instructions

 **Tip: Questions are even better than answers**

SAY Scientists love it when they don't have an answer to a question or problem, because that means they get to experiment to find it. The adventure and the fun is in the process. If you have questions during the Imagine Your STEM Future series, you might find answers:

- Online (Remember to check more than one source!)
- By asking a science or math teacher
- By talking to a sales expert, such as in a computer or electronics store

▶ **DO** Let girls know it doesn't matter what their design sketch looks like—it's all about the ideas. Some fantastic science concepts have come from doodles.

▶ **DO** Invite girls to share their new products, as well as the assumptions they made about the future to inform their designs.

▶ **ASK** *What are the coolest features of your product? Why do you think they'll be useful to users 10 years from now?*

Could you imagine yourself really creating this product?

What kind of scientific discoveries would need to happen for your product to be possible?

What will the world look like in 50 years?

How would your product need to change for users in that future world?

Sample response *"A future phone might be connected to your brain so it could transmit your thoughts—and understand where you mean to send each thought, without a phone number."*

Girls might want to design their product for a user 50 years in the future. Ask girls:

What will the world look like in 50 years?

How would your product need to change for users in that future world?

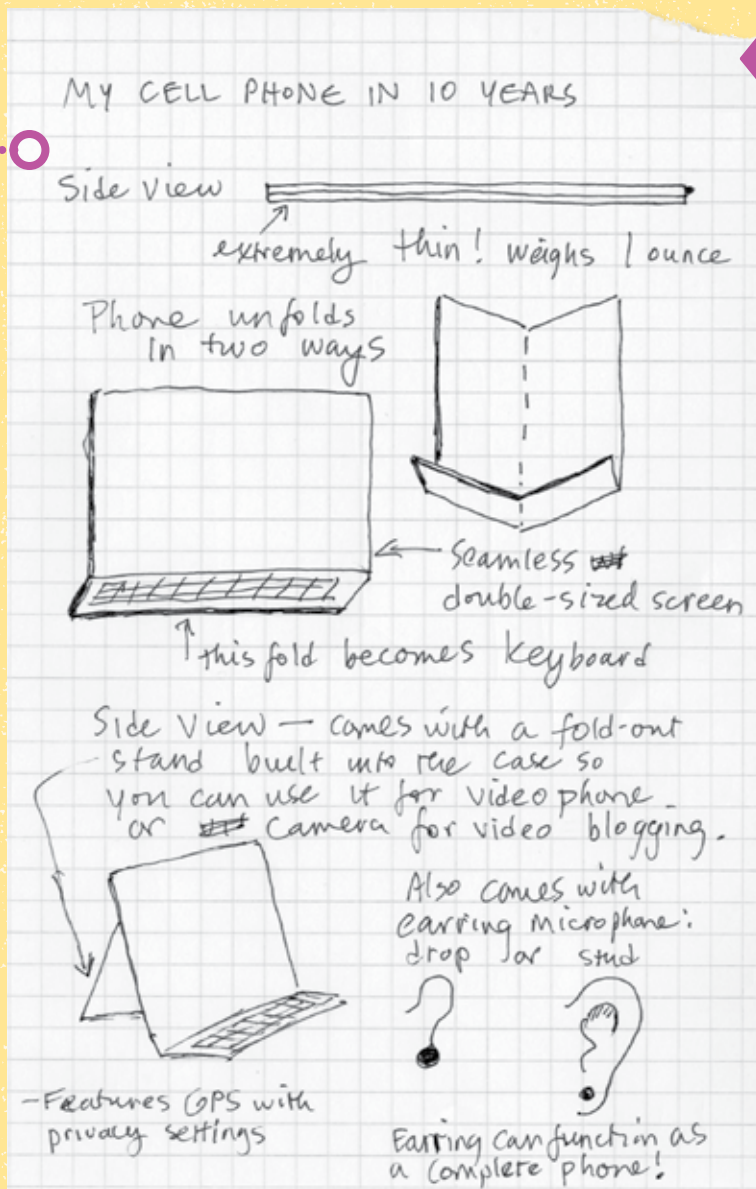
Sample response *"A future phone might be connected to your brain so it could transmit your thoughts—and understand where you mean to send each thought, without a phone number."*

IT'S OK TO MAKE MISTAKES.
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STEP 2: CREATE YOUR DESIGN

How will your product look in 10 years?

Show your idea in a detailed diagram, with call-out arrows explaining the different parts and what they do. Draw your diagram on a Design the Future card or in your lab notebook.



Call-Out Ideas

You might jot down thoughts on these categories:

Safety Example: *Is the covering on my product shatterproof?*

Materials Example: *Will I use materials that exist now or ones that I imagine in the future?*

Production value Example: *Does my product use affordable and available materials?*

Special features Example: *Is my product user-friendly?*

Environmental impact Example: *Is it reusable or recyclable?*

The Big Picture

Understanding how your product fits into the world at large can help you imagine where it will be in the future! Think about:

Social trends Example: *What do teens use cell phones for most?*

Technological advances Example: *How can 3-D technology be applied to music videos on MP3 players?*

Business applications Example: *What will interactive advertising on kiosks and billboards look like?*

Community/global functions Example: *Could a personal device detect water or air pollution?*

IMAGINE MORE

DESIGN A FUTURE CITY

Use found objects to create your vision of a futuristic town or city. Ask your volunteer to share the details about how you can do this.



Inspired? Now imagine your product in 50 years.



IMAGINE MORE: DESIGN AND CREATE A FUTURE CITY

ACTIVITY GOAL To get girls to problem solve while designing a future city

TIME Approximately 30 minutes

TEAMS Girls can work in teams of 10 or less

PLANNING BRIEF Girls are city engineers, planners, and architects. They use found or everyday objects to create a model of a futuristic town or city—thinking about parks, power, water, renewable energy, transportation, schools, and more.

Make sure to let girls know they can choose this optional activity if there is time and interest.

STEP 1: PLAN IT

SAY One way to determine what, where, and how much to build is to list all the possible requirements a city might have. You might also think about redesigning the city you live in, with an eye toward improving it for the future.

DO Invite girls to look at the role cards on the opposite page to help them start listing ideas for what their city will need. Where will people work? Shop? Go to school? What kinds of parks, playgrounds, libraries, and museums will the city have? What types of services (police, fire, medical, education) will be provided? What will be the main method of transportation? What about renewable energy sources?

STEP 2: BUILD IT

DO Girls on each team select roles from the cards on the opposite page, consider some of the questions, and begin building their cities.

STEP 3: SHARE IT

DO Invite girls to present their cities.

ASK

- What features attract people and businesses to your city?
- Are your emergency services in a location with easy access?
- Can your city accommodate a rapid growth rate?
- What were your challenges, and how did you solve them?

Sustainable Urban Planner

YOUR JOB To focus on your city's environmental care, but think about social and political needs as well.

How will you tie cleaner and greener homes, offices, and vehicles, and transportation into a cohesive city structure? What will you do about urban sprawl and excess pollution? Perhaps construct vertical farming (on rooftops) and create eco-villages as suburbs?

Energy Resources Engineer

YOUR JOB To find ways to produce energy through natural sources, such as through biofuels, wind, and solar power.

Where does your city's energy come from? What are your alternatives to electricity and oil? Will it be wind turbines? Solar? Safe atomic fission? Where are your alternative energy resources located (are they in a safe place?), and how do they power the city?

Waste Management Engineer

YOUR JOB To design and plan efficient ways to get rid of waste and environmental hazards, and to work on technology to assist with controlling pollution.

With people, there will be waste and landfills. Think of ways to break down and eliminate the refuse that can clog waterways and land. Don't forget about solutions for discarded computers, flat screens, portable phones, and other e-waste.

Transportation Engineer

YOUR JOB To develop plans for transportation systems—like airports, commuter trains, streets, highways, bridges, drainage structures, and roadway lighting—and be able to forecast for growth.

How will you move people from point A to B in the fastest, safest, and most energy-efficient ways? Will you build a light-rail system or air mobiles? If so, how will you control air traffic? Will your city be car free?

Landscape Architect

YOUR JOB To plan and design open spaces, like parks, gardens, city facilities, and the land around transportation systems.

Where will the parks, playgrounds, and recreation areas be? How much nature will your city have? Will your plants and trees have low-to-no irrigation needs? How will you conserve natural habitats?

City Planner

YOUR JOB To oversee your city's design and creation by considering the character, identity, pedestrians, traffic, utilities, safety, crime, and natural hazards of your city.

How will you set up residential, recreational, retail, and industrial zones? How will you assure safety and traffic flow in each zone? Will you require codes for buildings, such as limits on height?

Urban Engineer

YOUR JOB To implement the plan for your city by constructing and maintaining your city's networks, infrastructures, and services.

How will your sidewalks, street lighting, and transportation systems work? Where will power be generated? Do you have a way to collect and dispose of garbage? Prevent graffiti? How will your city accommodate growth?

Wild Card!

YOUR JOB What's a job we may need in the future that doesn't exist yet? Think one up and have some fun!

What kind of problems will you be trying to solve? For example, to help solve crime, you would be a biometrics identification specialist who identifies people based on eye, palm, or voice scans. Natural disasters? You might be a weather modification expert who can manipulate temperatures and storm systems.

SORT YOURSELF!

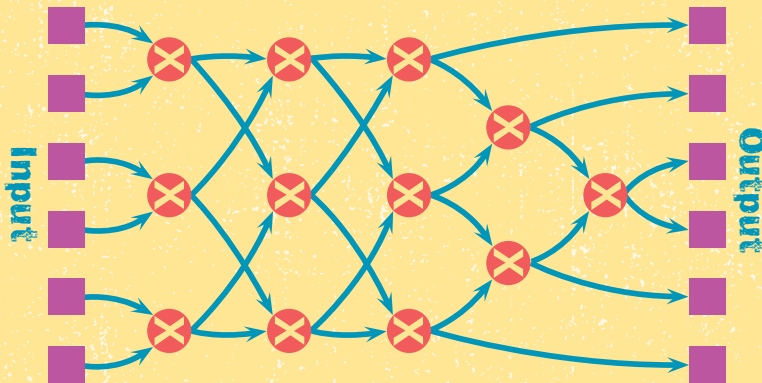
YOU ARE A COMPUTER SCIENTIST. Computer scientists come up with creative algorithms that tell computers how to sort and process huge amounts of information efficiently.

Programming Brief

Even fast computers are limited by how quickly they can solve problems. To speed processing, computer scientists are developing ways to have multiple processors work on parts of a problem at the same time. Here, you'll re-create sorting networks that are used to explore how much processing can be done concurrently to rapidly sort values into order.

STEP 1: PICK A NUMBER

- Team up in groups of six.
- Choose any number and write it on a sticky note.
- Copy the sorting network (shown below) on a floor or a pavement, using painter's tape or chalk, or use a plastic drop cloth or shower curtain so you can reuse it. If you have the time and space, you can create more than one diagram.



STEP 2: SORT IT OUT

- Each girl from your team stands in front of an arrow on the **INPUT** side of the network. Each team will take a turn.
- Move forward on your arrow. When you reach a node, wait for someone else to arrive and then compare numbers.
- The girl with the smaller number follows the line on the left. The girl with the bigger number follows the line on the right.

Materials

- Lab notebook and pen
- Painter's tape or chalk
- Sticky notes
- Timer (cell phone, clock, watch, or kitchen timer)

What's an algorithm?

An algorithm is a set of instructions that helps complete a task. Everything you do on a computer—even turning it on—relies on math-based algorithms developed by a computer scientist.

Imagine if you searched for something on the Internet and your computer looked through every single Web page before finding what you wanted, or if you typed an address into a GPS and it explored every possible route to your destination. That would be way too slow, and for these cases fast algorithms have been developed to search for key words and to find the shortest route quickly!

Thanks to csunplugged.org for this activity.

COMPUTER SCIENCE
Unplugged

Volunteer Instructions

ACTIVITY 3: SORT YOURSELF!

ACTIVITY GOAL To engage girls in a fun computer science activity that uses problem solving and logical reasoning skills

TIME Approximately 30 minutes

TEAMS Girls work in teams of six for the first sorting activity and in teams of four for the network showdown

SAY Computer scientists use computers to create all sorts of programs. Like to animate a 3-D video game. Or make music tracks smaller so they fit on a portable device. Or track historical weather patterns to help predict future ones. All these exciting programs begin with a set of instructions—called algorithms—that solve problems and enable us to build complex systems. Here, you're the computer scientist.

SAY Being able to sort data into order is important on computers—imagine a phone book and how it's organized in alphabetical order. Now think about how a computer sorts your information, whether by file size, alphabetical order, or date. To sort data, computers have to compare each value—as we'll do here.

TIP If you didn't have time before the meeting to create two copies of the sorting network on a floor or outside on pavement, ask the girls to make them now with painter's tape or chalk. Remind girls that the network must be large enough for them to walk through. If you've prepared only one network, let girls know that teams will have to take turns.

DO Make sure the girls' numbers are in random order when they line up on the input side.

If girls are having trouble, remind them to wait for the other girl to reach the node before comparing and moving on.

At the output, girls should be standing in numerical order, lowest number on the left, highest on the right.

The Sorting Diagram



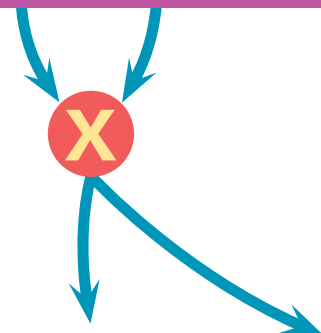
Here's a detail of a sorting diagram made with painter's tape on a rug. Make the diagram about 8 feet wide and 12 feet long. The nodes can be simple Xs of tape.

TIP To make diagrams reusable and movable, use painter's tape on a large drop cloth or shower curtain.

For a full-page printout of the sorting diagram shown at left, go to forgirls.girlscouts.org/imagine.

Science to Share: NODES

SAY The circles are called the comparison nodes of the network, where the computer checks each number and sorts it according to its value.




Volunteer Instructions

Science to Share: PARALLEL POWER

SAY In the past, computers could only execute one instruction after another—serial processing. Now some systems allow multiple instructions at the same time—parallel processing. Scientists are trying to find the best ways to break up problems so they can be solved in parallel.

Sorting networks offer one approach and could speed up processing by comparing more than one pair of values at a time. At present they are still experimental.

In the six-number sorting network in Step 1, although a total of 12 comparison nodes are used, up to three comparisons are performed simultaneously. This means that the time required would be that needed for just five comparison steps. This parallel sorting network sorts the list more than twice as quickly as a serial-processing system!

 **Tip** The sorting network shown in “More Sorting Challenges” can be used to find the minimum or maximum value of the inputs.

▶ **DO** Time each team’s sort. Let girls know who was fastest!

▶ **DO** Invite girls to experiment.

If girls start in the sorted order, they will find that moving backward from output to input reverses the order; if they start in a random order, the network may not sort correctly.

When girls change the order, they should end up at the output side of the network sorted in reverse order.

When girls sort in alphabetical order, the key is how they decide to sort: If letters earlier in the alphabet go left, the network will output A–Z order from left to right; if earlier letters go right, Z–A order.

▶ **DO** Share the background from Science to Share: PARALLEL POWER (at left).

▶ **ASK** Once girls have completed step 5:

How does network A work?

Sample response “It uses nodes making comparisons simultaneously.”

Is network A an example of parallel processing?

How would you describe network B?

Sample response “It uses only one node at a time.”

Explain that this network requires all comparisons in the nodes to be done serially, which means one after the other.

Why do you think parallel processing works faster?

Sample response “Because it divides the program instructions among multiple processors, working at the same time.”

What tasks or jobs in everyday life can only be done in sequence?

Sample responses “Putting socks and shoes on.”
“Digging a hole for a well.”

What can be accelerated using parallelism?

Sample response “Cooking a meal. Using only one burner, items would have to be cooked one after the other.”

- Continue this way until you reach the end of the network—the **OUTPUT** side.
- Once you reach the end of the network, read your numbers aloud one by one. *What order are you in?*

TIP If the sort was unsuccessful, try it again. Make sure your team is clear on the directions!

STEP 3: STEP IT UP

- Start in a different order and run your network again. Now you'll be timed. How did your team do?

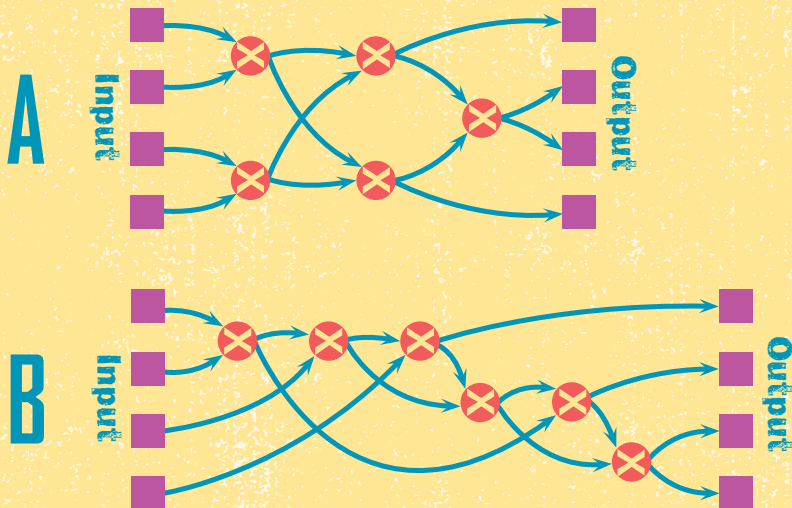
STEP 4: MIX IT UP

- Try it backward! *What happens when you move backward on the network from output to input?*
- Change the order! Have the girl with the smaller number go right instead of left. *What's the output now?*
- Use words! Write any word on a sticky note, and team up to use your network to end up in alphabetical order.

STEP 5: NETWORK SHOWDOWN

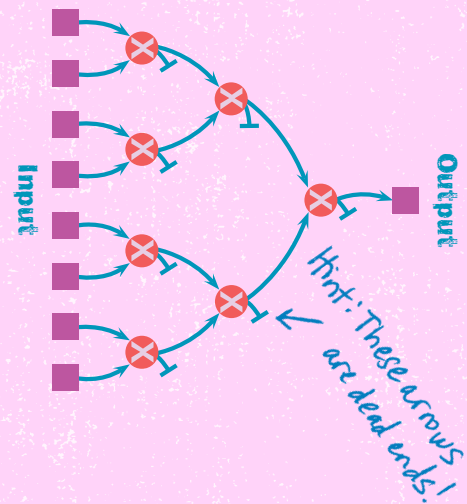
The diagrams below show two different networks that will sort four inputs. Using painter's tape or chalk, one team should make network A, while the other team makes network B.

- Compete with the other team to see which network sorts the fastest. *Why do you think it was faster?*



More Sorting Challenges

- Try designing smaller or larger networks in your lab notebook and then testing them on the ground, starting with a network for three sorting inputs. **TIP** When devising a new network, test more than one set of inputs to make sure it always sorts correctly!
- What does the network configuration below achieve? How would you modify it to use six inputs instead of eight?



IMAGINE MORE

QUICK SORT CARDS

Use a deck of playing cards for another fun way to come up with creative algorithms that tell computers how to sort and process. Ask your volunteer to share the details about how you can do this.



IMAGINE MORE: QUICK SORT CARDS

ACTIVITY GOAL To get girls to come up with a creative solution to a data sorting problem and write the explanation as a series of commands (algorithm)

TIME Approximately 30 minutes

TEAMS Girls work in teams of four; each team has one deck of cards

Make sure to let girls know they can choose this optional activity if there is time and interest.

PROGRAMMING BRIEF Girls are computer scientists and create an algorithm to sort data (playing cards) efficiently

STEP 1: SET IT UP

SAY Information is easier to find in a sorted list—like a telephone directory, a dictionary, or a Google search—so computer scientists continue to invent better and faster ways to sort data. In the last activity, we sorted numbers by parallel processing, comparing many values simultaneously. This time our (imaginary) computer is limited to serial processing—one comparison at a time.

The challenge for your team is to come up with a procedure (algorithm) to efficiently sort a suit of cards from lowest to highest value. **There's one rule: You can only compare values of two cards at once.** There are many possible sorting methods, but some take fewer comparisons and so are more efficient.

STEP 2: CREATE AND TEST

DO Invite girls to divide their decks into suits, and give one suit to each girl. Tell the girls to shuffle their cards at least two times.

Guide each team to come up with a method for sorting cards by value, and write down the steps in plain English—no programming language required! Each girl tests her team's method by following the instructions with her suit and counting the number of comparisons needed to put the cards in order.

STEP 3: COMPARE RESULTS

Teams compare methods. Results will vary, even when girls follow the same set of instructions. Why? Which team's sorting algorithm required—on average—the fewest comparisons?



Divide and Conquer!

SAY This Quick Sort method is an efficient way to sort cards from low to high value. The trick is to select a "chosen" card and compare others with it, repeating the sequence until all the cards are lined up in order. Remember to compare only two cards at once.

DO Give each girl a shuffled suit of cards and invite her to follow this sequence of steps. (See diagram below.)

- A** Hold cards facedown. Place top card (card #1) faceup on the table.
- B** Compare cards, one at a time, to card #1, stacking higher cards on the right and lower cards on the left. Count each comparison.
- C** Leave card #1 faceup.



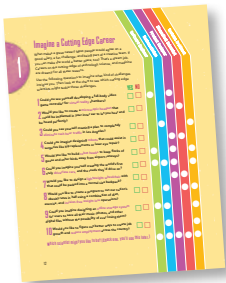
REPEAT **A B C** with stack of lower value cards, placing the top card (card #2) to the left of card #1 and sorting around it. **TIP** Higher cards will go between cards #2 and #1, unless card #2 happens to be the highest value card in the stack.

REPEAT **A B C** with stack of higher value cards, placing chosen card #3 to the right of card #1. Continue until cards are lined up in the order below.

ASK How many comparisons did it take? Does the value of the chosen card matter?

CLOSING CEREMONY: CAREERS ON THE CUTTING EDGE

STEP 1: DIG INTO CAREERS



DO Ask girls to turn to the Unit 1 career checklist on page 16 of their *Imagine Your STEM Future Girl Book*.

SAY *You used imagination and problem-solving to design the future and analyze networks. Scientists on the cutting edge use these skills every day. Now take a couple of minutes to imagine yourself in one of these jobs.*

ASK What do you think makes a dream job?

Which of these careers could you imagine yourself doing? Why?

What problems would you solve if you were a...?

What skills would you need to have to be a...?

STEP 2: MAKE LEADERSHIP CONNECTIONS

S DO Refer to "Shared Visions of GIRLtopia" (page 39 of *GIRLtopia Adult Guide*). Invite girls to answer: *In an ideal world, scientists could _____.*

SAY *As a scientist, you could be part of the solution to help get to your vision of GIRLtopia. What do you think stands in your way of becoming a scientist?*



A DO Ask girls to jot down their dreams onto inch-wide strips of paper. Refer to "Curtain of Dreams" (pages 40-41 of *BLISS Adult Guide*). Hold strips of paper for next meeting where girls will create their curtain.

SAY *Making your dreams come true is a big—and possible—goal. Leaders, especially in science, give themselves the space to dream big and then problem-solve to get there. Often one dream will trigger another dream.*

LOOK AHEAD: Ask girls if they are interested in doing the next unit's Imagine More activities so you can plan for materials.

Remind girls to bring their Imagine book, Journey book, lab notebook, and pen to EVERY meeting!

Spark the Conversation

DO Point girls to a scientist's profile in their *Imagine Your STEM Future* book and ask a targeted question. Example, page 12:

SAY *Shaundra Daily makes computers talk about feelings. Do you think talking with a computer about your feelings could be as effective as talking to a human?*

Or choose a career checklist question and answer it as a group! Ask the girls what about the career sounds intriguing and why.

Thought of the Day

Leaders and scientists
are problem solvers—
and so are you.

Your goal: to put the cards in order.
The catch: you have to think like a computer.

Imagine Yourself in a Lab



Unit 2 Overview

OPENING CEREMONY

Discovered in a Lab Girls think what is developed in a lab.

S "What's Our Ideal Group?" Girls set rules for teamwork.

A "When Values Collide" Girls discuss how values might affect their scientific team.

ACTIVITY 1: CUP PUZZLE

Girls use scientific reasoning to solve a puzzle.

ACTIVITY 2: EXTRACT DNA FROM A BANANA Girls learn about DNA matching.

IMAGINE MORE: Girls extract their own DNA.

S "Ethical Decision-Making" Girls look at ethics and DNA.

A "Line in the Sand" Girls explore values versus science.

ACTIVITY 3: FOOD SCIENCE CHALLENGE Girls create and analyze an emulsion.

IMAGINE MORE: Girls test gluten in flour.

CLOSING CEREMONY

Imagine You! Girls explore careers in a lab.

S "Envisioning GIRLtopia Through Art" Girls use art to imagine women in science.

A "Curtain of Dreams, Part 2" Girls see where their science dreams intersect.

KEY } **S** Grades 9–10
A Grades 11–12

Prepare Ahead

DOING TWO SESSIONS? The planner on page 3 shows you how.

ACTIVITY 1: CUP PUZZLE Each team gets six cups, three almost full of water, and three empty. Arrange the cups as shown in the illustration.

Save your cups to use again.

ACTIVITY 2: EXTRACT DNA FROM A BANANA

Chill the rubbing alcohol for half an hour, or bring it to the meeting packed in ice. Room temperature alcohol will work, but the results might not be as fast or as easy to observe.

OPENING CEREMONY

DO Ask girls to brainstorm things that were discovered in a lab.

Examples Aspirin, cameras, DNA, X-rays, Vaseline, stainless steel, Teflon, potato chips, penicillin, microwave ovens

SAY Discoveries happen when scientists find a solution to a problem, which may not have been obvious to others. Today, you'll be a forensic scientist and a food scientist, and you might make some discoveries of your own.

Make Leadership Connections

S DO "What's Our Ideal Group?" (page 45 of GIRLtopia Adult Guide).

SAY Scientists mostly work in teams where each have different specialties and support each other.

A DO "When Values Collide" (page 45 of BLISS Adult Guide).

SAY Think about the ways values play a role on a scientific team.

Unit 2 Materials

- S** GIRLtopia (Girl Book and Adult Guide)
- A** BLISS: Live It! Give It! (Girl Book and Adult Guide)
- Lab notebooks, pencils and pens
- 50 clear plastic cups, at least 9 oz. (for use in several experiments)
- Paper towels for cleanup
- Sticky notes
- Measuring teaspoons and tablespoons (or plastic spoons of equivalent measure)
- Access to tap water or 1 gallon bottled water
- Scissors

ACTIVITY 1: CUP PUZZLE

ACTIVITY GOAL To get girls using teamwork to solve the puzzle

TIME Approximately 10 minutes

TEAMS Girls work in three teams of four

STEP 1: DO THE PUZZLE

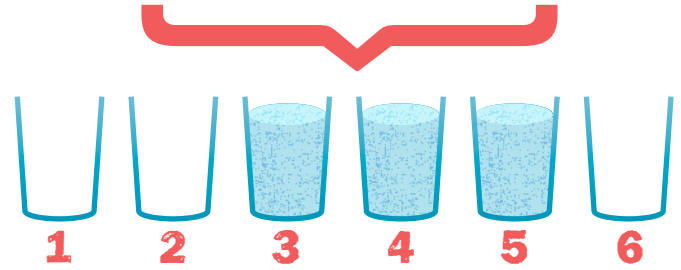
DO Invite girls to volunteer for different tasks, such as scientist, note taker, timekeeper, and observer.

SAY Each team has a set of six cups. Your challenge is to rearrange the cups so they stand alternately, one empty, one full. But here's the catch: You can move or touch only one cup to achieve this! You'll have five minutes to solve this puzzle. To solve the puzzle, you will need to pour water from cup No. 4 into empty cup No. 1 one and then return cup No. 4 to its original position.

STEP 2: QUESTION THE PROCESS

ASK Did the "no restrictions" tip help move you forward? What was your "aha moment" when you figured out the puzzle?

PREPARE AHEAD For each team, prepare six cups as shown below.



Tip: Reframe the Problem

Most often, girls will assume they can't pour water from one cup to another.

Suggest that they try to state the problem. **Example** We can touch only one glass to change the order of the six glasses.

Remind them that you didn't give any particular restrictions on their options. If they're still stumped, ask: What are the ways we can touch a cup?

EXTRACT DNA FROM A BANANA

Per team of two girls

- 1 banana
- 2 sealable plastic bags (quart size)
- Timer: watch, cell phone, etc.
- Cheesecloth, approx. 9" x 18"

To share

- Bottle liquid dish soap
- Box table salt
- Bottle rubbing alcohol (ethyl or isopropyl, 91% by volume, chilled)
- Toothpicks

IMAGINE MORE: EXTRACT YOUR OWN DNA

Same as banana extraction, but add:

Per girl

- Vial for keepsake (optional)

To share

- Bottle Gatorade (any flavor)
- Cord or beading wire for keepsake (optional)

FOOD SCIENCE CHALLENGE

Per team of two girls

- Two or more containers for mixing (can use plastic cups)
- Whisk (small if using plastic cups)

To share

- Mustard, honey, salt and pepper
- Flavorings: garlic powder and dried dill, oregano, and rosemary
- Olive oil, at least 750 ml
- Salad vinegar, at least 12 oz. (>TIP Darker vinegar, such as balsamic, makes emulsions easier to see.)
- 2 loaves French bread or washed lettuce leaves for taste testing

- 1 bottle commercial vinaigrette
- Plastic bottles to dispose of vinaigrette (oil might clog drains)

IMAGINE MORE: TEST GLUTEN IN FLOUR

- At least three different types of flour: all-purpose, bread, cake, instant, whole wheat, gluten-free
- Bowls (one for each flour tested)
- Measuring cups

CLOSING CEREMONY CURTAIN OF DREAMS, PART 2

- Glue or tape
- Paper
- Curtain rod (optional)

Imagine Yourself in a Lab

EXTRACT DNA FROM A BANANA

YOU ARE A FORENSIC SCIENTIST. That means you work in a lab to uncover the DNA (genetic code) that provides clues to a case. In a forensics lab it might be anything from a strand of hair to a leaf found in a suspect's car. Scientists compare the DNA from the crime scene with a suspect's DNA to see whether they match.

Forensic Brief

Team up with another girl to extract DNA from a banana. Isolating DNA from other chemicals in a sample allows scientists to analyze it. Record your results!

STEP 1: MAKE A FILTER

- Prepare a filter by cutting a piece of cheesecloth approximately 9" by 18".
- Fold it in half to make a two-layer strainer, about 9" square.
- Dampen the cheesecloth and drape it over a clear plastic cup.

STEP 2: MASH THE BANANA

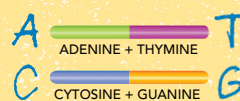
- Peel a banana and place half in a sealable plastic bag.
- Add four tablespoons of water. Seal the bag.
- Mash the banana and water together with your hands. Do this for about 2-3 minutes until you have a smooth mixture.

Materials

- Lab notebook and pen or pencil
- Scissors
- Cheesecloth
- Clear plastic cups
- ½ peeled banana
- Sealable plastic bag
- 4 tablespoons (¼ cup) plus 4 teaspoons water
- 1 teaspoon liquid soap
- 2 pinches table salt
- Plastic spoon for stirring
- Timer (cell phone, clock, watch, or kitchen timer)
- 2 teaspoons rubbing alcohol (for best results, use ethyl or isopropyl alcohol, 91% by volume, chilled)
- Toothpicks

DNA (deoxyribonucleic acid) is a molecule that stores genetic information. Individual strands of DNA are so tiny they can't even be seen through a microscope.

Base pairs of DNA Each strand of DNA is made up of tiny building blocks called bases (known as A, T, C, and G), paired like the rungs of a ladder in this double helix shape.



2

Volunteer Instructions

ACTIVITY 2: EXTRACT DNA FROM A BANANA

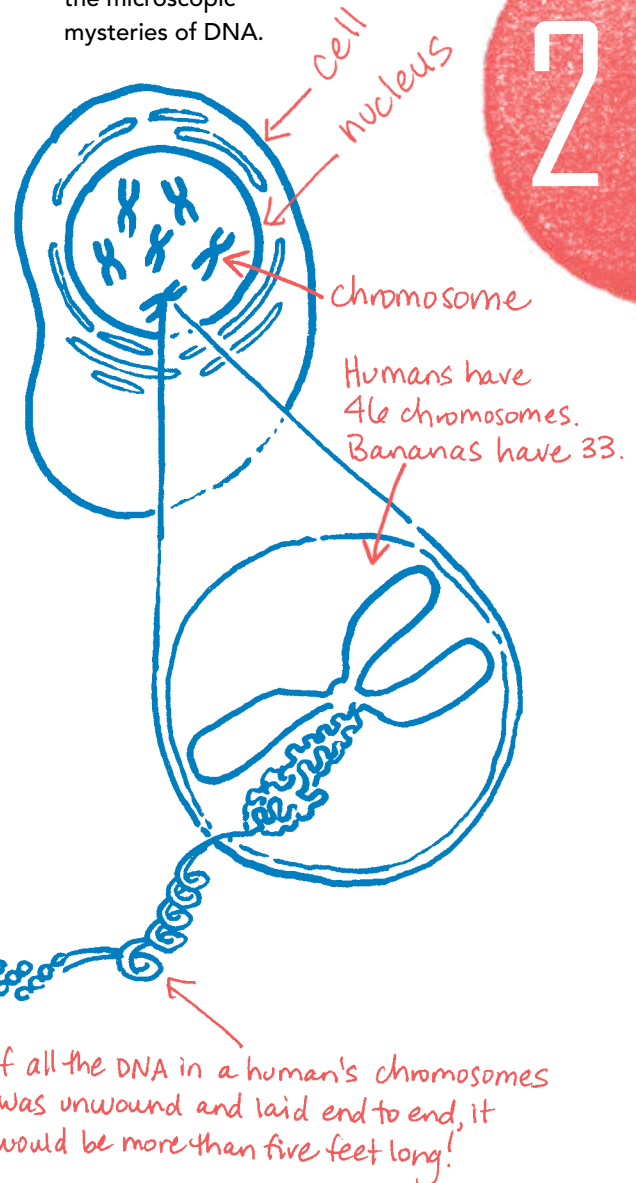
ACTIVITY GOAL To engage girls in lab work as they extract DNA from a banana

TIME Approximately 30 minutes

TEAMS Girls work in pairs

Science to Share: INSIDE CELLS

This diagram unravels the microscopic mysteries of DNA.



SAY As a forensic scientist, your job might be to investigate and examine evidence from a crime scene. For example, you might find a paint chip on a hit-and-run victim that matches a rare vintage car. Or discover a flammable material in fire debris. Or study the DNA of saliva from a crime scene. The tiniest clues can solve the biggest cases, and most of the discovery happens in a lab, where you'd work with everything from chemicals to microscopes and lasers. As you extract DNA from a banana, imagine being a forensic scientist.

DO Remind girls to wet the cheesecloth and squeeze it dry before placing it over cup. This keeps the cloth in place during the filtering.

SAY By mashing the banana, you are breaking down its cells to release the DNA, most of which is within the cell nucleus. Crush the banana to as smooth a texture as you can to separate as many cells as possible.

Volunteer Instructions

Stir It Up...

DO Share some of the reasons scientists study DNA:

- Work with crime science investigators to help solve crimes
- Modify foods to be insect resistant
- Reconstruct biological history by decoding the DNA of extinct species
- Make new medicines or medical discoveries
- Trace ancestors or family through genetic testing

ASK Can you think of more?

Sample responses

"Find a cure for cancer."
 "Test for a baby's paternity."

▶ **SAY** Soap helps break down cell membranes and release the DNA. The salt helps bring the DNA strands together.

▶ **TIP** Remind girls to stir gently to avoid getting bubbles in the mixture and making it sudsy.

▶ **SAY** You are collecting the liquid containing DNA and separating it from the banana's cell remnants and tissue.

▶ **TIP** If the cloth strainer isn't staying in place, one of the team members should hold it while the other pours.

DO Suggest that girls record observations in their lab notebooks. For instance, is the liquid clear or colored? What is its consistency?

▶ **SAY** During the process, the alcohol helps the DNA precipitate and come out of the solution so it can be collected.

▶ **DO** Let girls know that the DNA might become fragmented during the original steps and can't be lifted in long strands. But there should be enough blobs in the girls' mixtures to observe and to pick up on a toothpick.

ASK Have you heard of DNA matching being used to convict a suspect or to free a prisoner wrongly convicted of a crime?

Would you take a DNA test to find out if you had a high risk of developing a certain disease? Why or why not?



STEP 3: MIX THE SOLUTION

- In a clear plastic cup, mix 1 teaspoon of liquid soap, 2 pinches of table salt, and 4 teaspoons of water.
- Slowly stir with a plastic spoon to dissolve the salt and soap in the water.
- Add 2 tablespoons of the banana mash to the solution.
- Stir continuously with a spoon for 5 minutes. Time it!

STEP 4: STRAIN

- Pour the banana-soap mixture into the cheesecloth filter—hold the filter in place so it doesn't fall into the cup.
- Let the mixture drain for several minutes. You should get a clear solution in the cup.

STEP 5: PRECIPITATE

"Precipitating" is creating a chemical reaction that causes an insoluble substance (one that won't dissolve) to emerge from a liquid mixture.

- Add 2 teaspoons of rubbing alcohol to the banana-soap mixture in the cup. Hold the cup and gently swirl. Do not stir!
- You should see the DNA begin to separate from the solution. It has the appearance of white, stringy mucus.

STEP 6: EXTRACT THE DNA

- After about 5 minutes, use a toothpick to remove the DNA, or scoop it up with a spoon and tip out the excess liquid.



You're looking at billions and billions of tangled strands of DNA—sticking together like cold spaghetti.

It's All in the Code!

All living organisms contain DNA, so what makes us unique? Not as much as you think! We share surprisingly high percentages of DNA sequences with other organisms, especially mammals.

- **Chimpanzee** 98% similar to human
- **Mouse** 92%
- **Fruit fly** 44%
- **Yeast** 26%
- **A weed** 18%

IMAGINE MORE

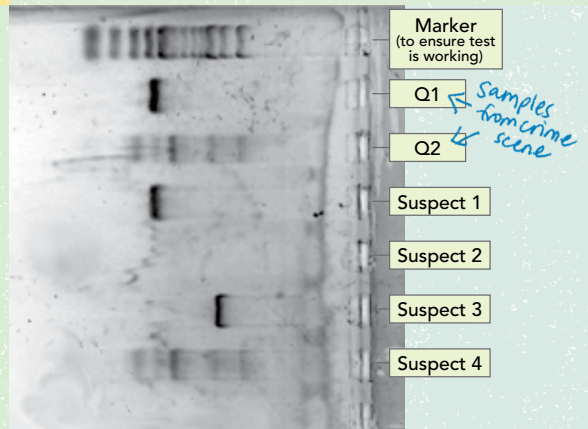
EXTRACT YOUR OWN DNA

Only one-tenth of a percent of DNA differs from one person to the next, yet those small differences make each of us unique. Isolate a sample of your DNA — your molecular signature. Ask your volunteer to share the details about how you can do this.

2

DNA Matching: What Happens Next?

Extracting human DNA strands from crime scene samples starts with a process similar to the one you just performed. Next, the forensic scientist might perform a gel electrophoresis. In this process, molecules of DNA are pushed through a gel by electric current. As the molecules move through the gel, they form bands on the gel: larger molecules form larger bands. The scientist can then look for repeating sequences in 13 different genetic regions. There is only a one in one billion chance that two people will match on all regions. So if the patterns repeat on both the suspect's sample and the questioned (evidence) sample, the suspect can be exposed.



In this DNA gel, it looks like two of these four suspects might have been at the scene of the crime.



IMAGINE MORE: EXTRACT YOUR OWN DNA

ACTIVITY GOAL To give girls a personal connection to DNA gathering

TIME Approximately 30 minutes

TEAMS Girls can work alone or with a partner

Make sure to let girls know they can choose this optional activity if there is time and interest.

STEP 1: MIX THE SOLUTION

DO Tell girls to pour 1 teaspoon of clear liquid soap into a clear plastic cup. Ask them to gently chew on their cheeks to break up cells. Then swirl 2 teaspoons of Gatorade (or salt-and-water solution) in their mouths vigorously for 30 seconds. Make sure they don't swallow! Have them spit Gatorade into the cup with clear soap. Then gently mix with a plastic spoon for 2–3 minutes.

TIP Avoid creating too many bubbles.

STEP 2: PRECIPITATE

DO Have girls tilt the cup with the solution and gently pour 2–3 teaspoons of the cold alcohol down the inside side of the container so that it forms a layer on the top. Tell them not to mix! Girls will see the DNA begin to separate from the solution. It has the appearance of white, stringy mucus.

SAY *This is your DNA! DNA does not dissolve in alcohol; instead, it forms a solid where the alcohol and salt-water layers (contained in Gatorade) meet. The white strings and clumps are thousands of your DNA lumped together. Single DNA molecules are too small to be visible to the eye.*

STEP 3: EXTRACT DNA

DO After about five minutes, have girls use a toothpick to gently spool the white clumps around it and transfer the precipitated DNA into a vial. Tell them to use the teaspoon to put a small amount (approximately 1 ml) of the cup's leftover alcohol solution into a vial and seal tightly.



The DNA yield girls get extracting their own is much less than the DNA a banana will yield.

2

STEP 4: WEAR IT! (OPTIONAL)

SAY Your DNA can last for years if stored in alcohol in a tightly sealed container. If shaken, the DNA strands will break into smaller pieces.

DO Invite girls to use a cord or beading wire to tie around the vial and make a DNA keepsake.

SAY Artists have used their DNA as ink to sign their paintings and prevent forgeries. Besides investigating crimes, can you think of other ways your DNA can be used?

Sample responses "To clone a person 50 years from now."
"To identify a genetic disorder."

S DO

"Ethical Decision-Making" (page 65 of *GIRLtopia Adult Guide*). Invite girls to discuss the ethics of DNA. For example, should a person's DNA code be private or public information?

Make Leadership Connections

A DO

"Line in the Sand" (page 46 of *BLISS Adult Guide*). Invite girls to discuss values and what defines gray or black-and-white areas. For example: When is it okay to share a person's vital DNA information with a family member? Does it depend on the degree of genetic variability or on the seriousness of the illness?

Even with powerful atomic force microscopes, scientists can't see DNA molecules in enough detail to "read" the chemical bases that make up the rungs of the DNA ladder. They use other techniques, as explained in "DNA Matching: What Happens Next?" on page 19 of the *Girl Book*, to determine the small differences that make each of us unique.

2

FOOD SCIENCE CHALLENGE

YOU ARE A FOOD SCIENTIST. Food scientists use math, chemistry, and imagination to create new food products that are delicious and marketable—like low-fat ice cream, yogurt in a tube, or a new potato chip flavor. They test their creations to decide which products move out of the lab and into the marketplace.

New Product Brief

Team up with another girl to make two vinaigrettes, then choose the best one to submit to the blind tasting panel.

STEP 1: PREPARE THE BASIC VINAIGRETTE

- Review **The Science of Emulsions** on the next page.
- Follow the recipe. Record in your notebook which emulsifier you chose, how long you whisked, and a description of the resulting emulsion. *Are there visible droplets of oil or vinegar? Do you see layers?* **>Tip** Tilt the cup to check consistency. An oil-in-water emulsion looks a bit like a glob.

STEP 2: DEVELOP YOUR RECIPE

- Choose flavorings you think will taste good with your vinaigrette base. You might want to taste everything separately so you know each flavor.
- Add flavorings, tasting as you go. You may also want to adjust amounts of oil, vinegar, and emulsifier to taste. Whisk thoroughly to maintain your emulsion. Make sure to write down the amount of flavoring you add.
- Don't forget to keep records. You may have a winning recipe!

FLAVOR TIPS Creating a great flavor is a balancing act of the tastes people can detect: salts, sweet sugars, sour acids, bitter alkaloids, and savory amino acids. Salt enhances flavor; fats like oil help spread flavor across your tongue.

Materials

- Pen or pencil
- Lab notebook
- Teaspoon and tablespoon
- Clear plastic cups
- Mustard and/or honey
- Vinegar
- Oil
- Whisk
- Flavorings: salt, pepper, dill, oregano, garlic powder, rosemary
- French bread or lettuce
- Sticky notes
- Commercial vinaigrette

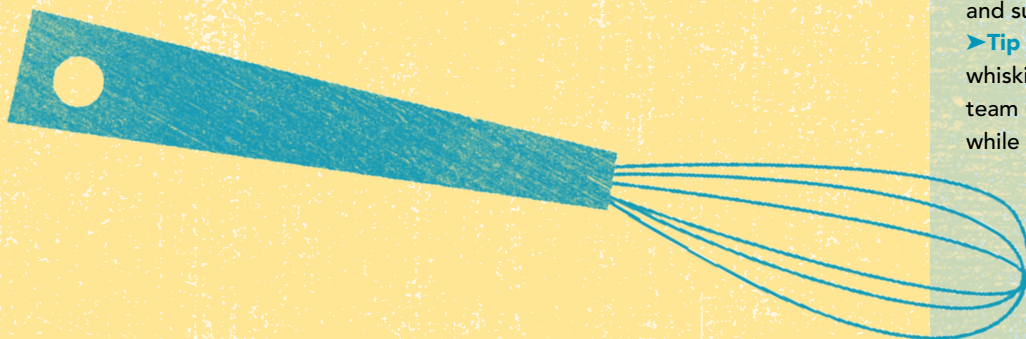
Vinaigrette Recipe

- 1 teaspoon emulsifier (mustard and/or honey)
- 1 tablespoon vinegar
- 3 tablespoons oil

Directions for Oil-in-Water Emulsion

Whisk together mustard and vinegar. Add oil drop by drop at first, and then in a thin stream, whisking continuously. This disperses the oil into thousands of tiny droplets, which are contained and surrounded by the vinegar. **>Tip** Tilt the cup for easier whisking. You may want to team up to take turns whisking while another girl adds oil.

2



Volunteer Instructions

ACTIVITY 3: FOOD SCIENCE CHALLENGE

ACTIVITY GOAL To get girls recording data and using math and chemistry to make a vinaigrette

TIME Approximately 30 minutes

TEAMS Girls work in six teams of two

SAY *Can you imagine a career in which you get to play with food? Food scientists create foods that are delicious and easy to replicate on a large scale. They also work on new ways to package and store foods, and sometimes develop new food products. Like peanut butter and jelly in the same jar. Or a vegetarian product that tastes and smells like meat.*

DO Review the brief. Girls might work together to make both vinaigrettes, or each make one and then compare.

SAY *The flavor of your final vinaigrette depends on the taste of the basic ingredients.*

DO Make a “control” vinaigrette. While girls are making their vinaigrettes, follow the recipe without using an emulsifier. Stir it vigorously with a clean spoon and set it aside. During the tasting panel the girls can compare it with the other vinaigrettes.

Science to Share: OIL AND LEAVES

SAY *Green leaves are naturally protected by a thin, waxy layer. Oil can seep past this layer, causing leaves to lose their crispness. So, oil-in-water emulsified vinaigrette—in which the vinegar surrounds the oil—helps a salad stay fresh and crunchy!*

DO Demonstrate this by dipping one lettuce leaf into oil and another into vinegar. After 10 minutes or so, they should notice more wilting in the oily leaf.

Troubleshoot

Before offering suggestions, ask girls what they think has happened, and how and why it happened.

Balancing Act

Proportions are important—the key ratio is three parts oil to one part vinegar, with at least one-third part emulsifier. Why? When oil droplets are crowded closely enough to be in consistent contact, they are more likely to pool together.

TIP If the vinaigrette seems too thin, girls can add more oil—slowly!

Adding the Oil Too Quickly

If the oil is added too quickly, the oil and vinegar switch roles in the emulsion. The oil becomes the continuous phase, the vinegar becomes dispersed in it, and the result is a water-in-oil emulsion—oily and thin.

Volunteer Instructions

Blind-Tasting Key

Sample	Names of Team Members
A	
B	
C	
D	
E	
F	
G	Commercial vinaigrette

DO Make sure the taste testing is blind, so girls don't know who made which vinaigrette. Tell girls to:

- Use sticky notes to label the cups from each of the six teams: a, b, c, d, e, f.
- Use the Blind-Tasting Key (at left) to keep a record of where each sample came from.
- Pour commercial vinaigrette into a seventh cup, and mark it G.
- Dip a fresh piece of bread or washed lettuce leaf into each cup to taste test.

DO Invite the teams to share their favorite flavors and discuss their lab process. Pass around the bottle of the commercial brand so girls can see the ingredients.

Inset from page 22 of the Girl Book

STEP 4: ANALYZE THE RESULTS

- Which vinaigrette received the highest ratings?
- Would you want to market the winning vinaigrette? What would you call it?
- How did the commercial vinaigrette rank? What ingredients does the commercial vinaigrette have that freshly made ones don't?
- Why might one kind of emulsion be preferred in a vinaigrette over the other?

Look below for some info on possible ingredients.

Added in the Lab

Common commercial **emulsifiers** are soy lecithin, mono- and diglyceride, polysorbates, and gums—often added in the lab to keep salad dressing, peanut butter, and ice cream looking smooth.

Other additives in commercial food products are used for different purposes, such as prolonging shelf life (recommended date for sale or use). For example:

Additive	Purpose	Made from	Used in
emulsifiers		fatty acids	muff

STEP 3: HELP CHOOSE A WINNER!

- Evaluate your team's vinaigrettes. Choose one to submit to the tasting panel. Give your selection to the volunteer with the recipe written on a sticky note.
- Join the tasting panel to judge seven products, including one that's already on the market! Score each vinaigrette based on whether it is an oil-in-water emulsion, and on the amount that the ingredients have separated. Then rate the aroma and taste of the vinaigrettes.
- Total your scores and share your findings with the panel.

RATINGS KEY

Emulsion Flavor, aroma

- | | |
|-------------------------|-------------|
| 1 Water-in-oil emulsion | 1 Okay |
| 2 Can't tell | 2 Good |
| 4 Oil-in-water emulsion | 3 Very good |
| | 4 Excellent |

Amount of Separation

Rate on a scale from 1 (completely separated into layers) to 4 (no visible layers).

Vinaigrette Ratings Grid

SAMPLE	A	B	C	D	E	F	G
Emulsion							
Separation							
Flavor							
Aroma							
Total Score							

2

The Science of Emulsions

An emulsion is a mixture of two liquids that don't dissolve in each other: one liquid (called the dispersed phase) is dispersed in the other (called the continuous phase).

Emulsions are all around us. Some common examples are milk, butter, mayonnaise, skin cream, lotions, floor and furniture waxes, some paints, asphalt, and crude oil.

By their nature, emulsions are temporary. Scientists help emulsions stay intact by using emulsifiers, molecules that help liquids bind together. Mustard, honey, and egg yolks are common cooking emulsifiers.

Vinaigrette Our recipe could produce two different types of emulsions—water-in-oil or oil-in-water—depending on the method used to mix the ingredients.



Water-in-Oil Emulsion

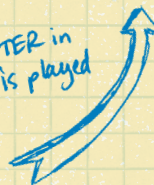
Here, vinegar is the dispersed phase and oil is the continuous phase. It's easy to make this kind of emulsion because there is more oil than water in the mixture. The emulsion is thinner and may look cloudy.



Oil-in-Water Emulsion

Here, oil is dispersed in water. The mixing method in our recipe ensures that vinegar remains the continuous phase, surrounding a larger amount of dispersed oil. The resulting emulsion is thicker and more stable.

The role of WATER in a vinaigrette is played by VINEGAR!





IMAGINE MORE: TEST GLUTEN IN FLOUR

ACTIVITY GOAL To get girls to use their observation skills while extracting gluten from flour

TIME 30–40 minutes

TEAMS Girls work in pairs

Make sure to let girls know they can choose this optional activity if there is time and interest.

Food Lab Brief

SAY When you knead wheat-flour dough, two proteins—gliadin and glutenin—form gluten. Without gluten, there would be nothing to hold the gas that makes bread rise. In this experiment, you will extract a ball of gluten from flour to see what it looks like.

STEP 1: PREPARE THE MIXTURE

DO Invite girls to measure out 1 cup of flour (and alternate flours, if they are using). Label each. Add ½ to ¾ cup water to each bowl. Have girls knead the mixture until it becomes a soft, rubbery ball of dough. Let it sit for about 10 minutes.

STEP 2: RINSE

DO Have girls run cold running water over one of the dough balls for at least five minutes. Make sure dough doesn't disintegrate.

>TIP Tell girls to cup their hands around the ball and squeeze gently to remove the starch. Or wrap dough in cheesecloth.

SAY When you run water over dough, you wash away most of these other substances, isolating the gluten.

STEP 3: OBSERVE AND REPEAT

DO Invite girls to notice the water turning milky as it washes away the starch in the dough. Tell them to keep pouring out the cloudy water that collects in the bottom of the bowl. When the water is no longer milky, their dough ball should be a pure gluten.

DO Invite girls to repeat steps with other flour types.

ASK Does the texture of each one differ as you wash away starch? Does it take the same amount of time for each one? Are the gluten balls all the same size?

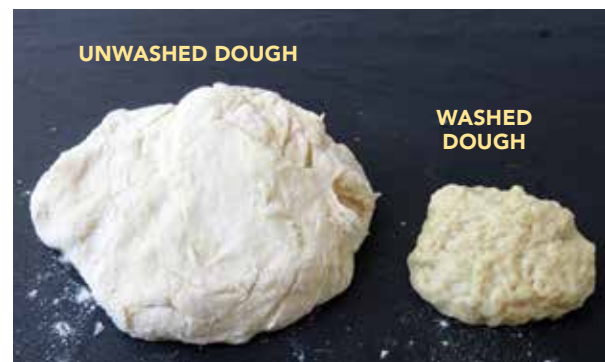
Science to Share: GLUTEN

Think of gluten as the rubber of a balloon. The stronger it is, the more gas it can hold. But stronger isn't always better: For baked goods like pastries and piecrusts, it's important to avoid gluten development. Different flours contain different amounts of protein, which makes them more suitable for different recipes: A high-protein flour will make a dough with strong gluten, good for hearty yeast breads. Pastry chefs prefer low-protein flours that yield tender dough.

Have time? Cook it!

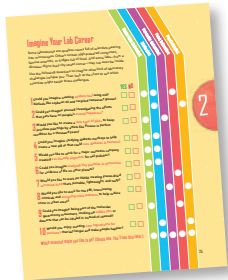
DO Invite girls to bake their gluten balls in an oven for 15–30 minutes at 450°F, until puffed.

ASK Why do you think the gluten changed its shape? What do you think happens as the gluten heats up? (In the oven, the steam produced as the gluten heats up expands and hardens the ball, which is what happens to gluten in bread as it bakes.)



CLOSING CEREMONY: CAREERS IN A LAB

STEP 1: DIG INTO CAREERS



DO Ask girls to turn to the Unit 2 career checklist on page 27 of their *Imagine Your STEM Future Girl Book*.

SAY You experimented with DNA extraction and created emulsions. These are just some of the many amazing things scientists do in their labs each day. Can you imagine having one of the lab careers profiled in your book?

ASK What do you love to do? How could you turn that into a job in a lab?

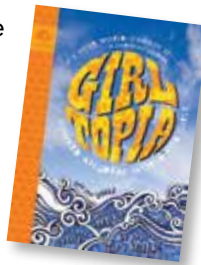
How could you make a difference in the world if you were a...?

What kind of education do you think you'd need to...?

STEP 2: MAKE LEADERSHIP CONNECTIONS

SAY Everyday interactions in life are like experiments that we all can use to understand our values and ourselves.

S DO "Envisioning GIRLtopia Through Art" (page 40 of *GIRLtopia Adult Guide*), but ask girls to use their art form—poetry, drawing, short story, or more—to communicate their vision for roles of women in science.



A DO Give girls the strips of paper with their dreams and invite them to create their curtain. Refer to "Curtain of Dreams" (pages 40–41 of *BLISS Adult Guide*) for how to create it. Invite girls to identify dreams that have anything to do with science, and find out how many of those intersect.

LOOK AHEAD Ask girls if they are interested in doing the next unit's *Imagine More* activities so you can plan for materials.

Remind girls to bring their *Imagine* book, *Journey* book, lab notebook, and pen to EVERY meeting!

Spark the Conversation

DO Point girls to a profile in Unit 2 of their *Imagine Your STEM Future Girl Book* and ask a targeted question. Example, page 23:

SAY Suzanne Lee wants to grow environmentally friendly clothes in her lab—literally. Would you want to wear "vegetable leather" clothing? Why or why not?

Or choose a career checklist question and answer it as a group! Ask the girls what about the career sounds intriguing and why.

2

Thought of the Day

Your life is a laboratory for discovering the values you use as a leader.

Imagine Yourself as an Engineer

Unit 3 Overview

OPENING CEREMONY

What Engineers Do Girls share perspectives on engineering.

S **"Girls' Bill of Rights"** Girls explore the need for women in engineering.

A **"A Symbol of Bliss"** Girls create a symbol to encourage women engineers.

ACTIVITY 1: HUMAN CIRCUIT Girls role-play a power connection.

ACTIVITY 2: SWITCH HITTER Girls design a buzzer system.

IMAGINE MORE: Girls test their buzzers in a game show.

S **"Sound Off: Thinking Outside the Box"** Girls brainstorm different qualities.

A **"What's Your Label?"** Girls recognize how labels might help or hurt a dream.

ACTIVITY 3: SOFT CIRCUIT TEXTILES Girls connect a light and battery to fabric.

IMAGINE MORE: Girls test properties in fabric.

CLOSING CEREMONY
Imagine You! Girls explore careers in engineering.

S **"'Create It' Time"** Girls envision a world that empowers women in STEM.

A **"Dreams on a Wire"** Girls talk about STEM careers.

Prepare Ahead

DOING TWO SESSIONS? The planner on page 3 shows you how.

ACTIVITY 1: HUMAN CIRCUIT On each of three sticky notes, write one of these: **BATTERY+**, **BATTERY-**, and **BUZZER**.

IMAGINE MORE: GAME SHOW Prepare questions on cards.

IMAGINE MORE: BE A FABRIC TESTER Cut fabric samples into 2" and 6" squares. Leave enough fabric to wrap plastic bottles (see photo, page 48). Label all samples with fabric type.

OPENING CEREMONY

DO Get a discussion going about women and engineering. Invite girls to read profiles in Unit 3 of their Girl Book, pages 32–36.

ASK *What do you think of when you hear the word engineer? How about mechanical engineer? Chemical engineer? Do you know any engineers? What kind of work do they do? What are some reasons girls should explore engineering careers?*

Sample responses *"Exciting travel opportunities." "Ability to help others." "Chance to collaborate with a team." "Money and job security." "Flexible work environment: in an office, telecommute on computer, or work in the field."*

Make Leadership Connections

S DO "Girls' Bill of Rights" (page 53 of *GIRLtopia* Adult Guide). Add this science focus: Have girls look at a statistic for women in engineering and come up with ways they might change it.

A DO "A Symbol of Bliss" (page 52 of *BLISS* Adult Guide). Invite girls to create a symbol that encourages women in engineering.

KEY } **S** Grades 9–10
A Grades 11–12

ACTIVITY 1: HUMAN CIRCUIT

ACTIVITY GOAL To get girls experiencing how electrons travel from negative to positive ends of a battery

TIME Approximately 10 minutes

STEP 1: REVIEW CIRCUITS

SAY Before you build an actual circuit, form this human circuit to understand it better: You will role play the battery as the power source, conductors to form a path, and a load—the buzzer. When a chemical reaction in a battery starts electrons moving, they travel around the circuit from the negative end of the battery to the positive end. Along the way, they power the buzzer. This flow is called current. Here, we'll use Ping-Pong balls as electrons.

STEP 2: CREATE THE CIRCUIT

DO Invite two girls to be the battery. One will be the positive terminal and wear a sticky note reading **BATTERY+**. The other, playing the negative terminal, will wear a note reading **BATTERY-**.

- Invite one girl to be the **BUZZER** and stand across the room from the battery girls. The rest of the girls act as **CONDUCTORS** form a circle linking the battery and buzzer.
- Give the **BATTERY-** girl four Ping-Pong ball “electrons.” She will pass them to the conductor beside her, who will pass them to the next conductor, and so on.
- When a ball reaches the buzzer, she'll buzz to show that electricity is “flowing” through her. Tell girls to keep the flow going around the circuit. Remind them that as long as the circle remains intact, it's a **closed circuit**.

STEP 3: SWITCH!

DO Ask girls to swing “open” in the circle at one spot to create a gap and demonstrate an **open circuit**. Remind girls that this is what happens when a circuit breaks and no electrons can flow. Invite one girl to be the **SWITCH**. When she steps away from the circle, she's in “off” mode, and the electrical charge cannot be completed. When she moves back into the circle, she is “on” and the flow can happen.

Unit 3 Materials

- S** *GIRLtopia* (Girl Book and Adult Guide)
- A** *BLISS: Live It! Give It!* (Girl Book and Adult Guide)
- Lab notebooks, pencils, pens, sticky notes

HUMAN CIRCUIT

- 4 Ping-Pong balls

SWITCH HITTER

Per team of four girls

- 2 AA batteries
- 2–3 wires with alligator clip leads
- 1 buzzer with positive and negative lead wires
- 4 sheets of 8½" x 11" chipboard

To share:

- 1 roll aluminum foil
- Office supplies: binder clips, paper clips, rubber bands, scissors, tape

SOFT CIRCUIT TEXTILES

Materials on page 45

IMAGINE MORE: GAME SHOW

- Index cards (at least 12)
- Timer (cell phone, clock, watch, or kitchen timer)
- More conductors: aluminum foil, pennies or other coins

IMAGINE MORE: FABRIC TESTING

- Different types of fabrics (see Test These Fibers! on page 48)
- Measuring cup
- Water
- Paper towels
- Timer
- Sandpaper (80 or 120 grit)
- Wire hairbrush or cheese grater (optional)
- Cooking thermometers, per team
- 3 empty water bottles per team

3

Imagine Yourself as an Engineer

SWITCH HITTER

YOU ARE AN ELECTRICAL ENGINEER. These engineers develop and design complex electrical systems that power our lives.

Circuit Brief:

Working in teams of four, build a circuit that makes a buzzer ring. Then you'll design and test two switches. Ask your volunteer for details on how to test your switches by doing the Imagine More Game Show.

STEP 1: BUILD A CIRCUIT

Build a simple circuit with the battery as a power source and the buzzer as your load (or device that uses the power).

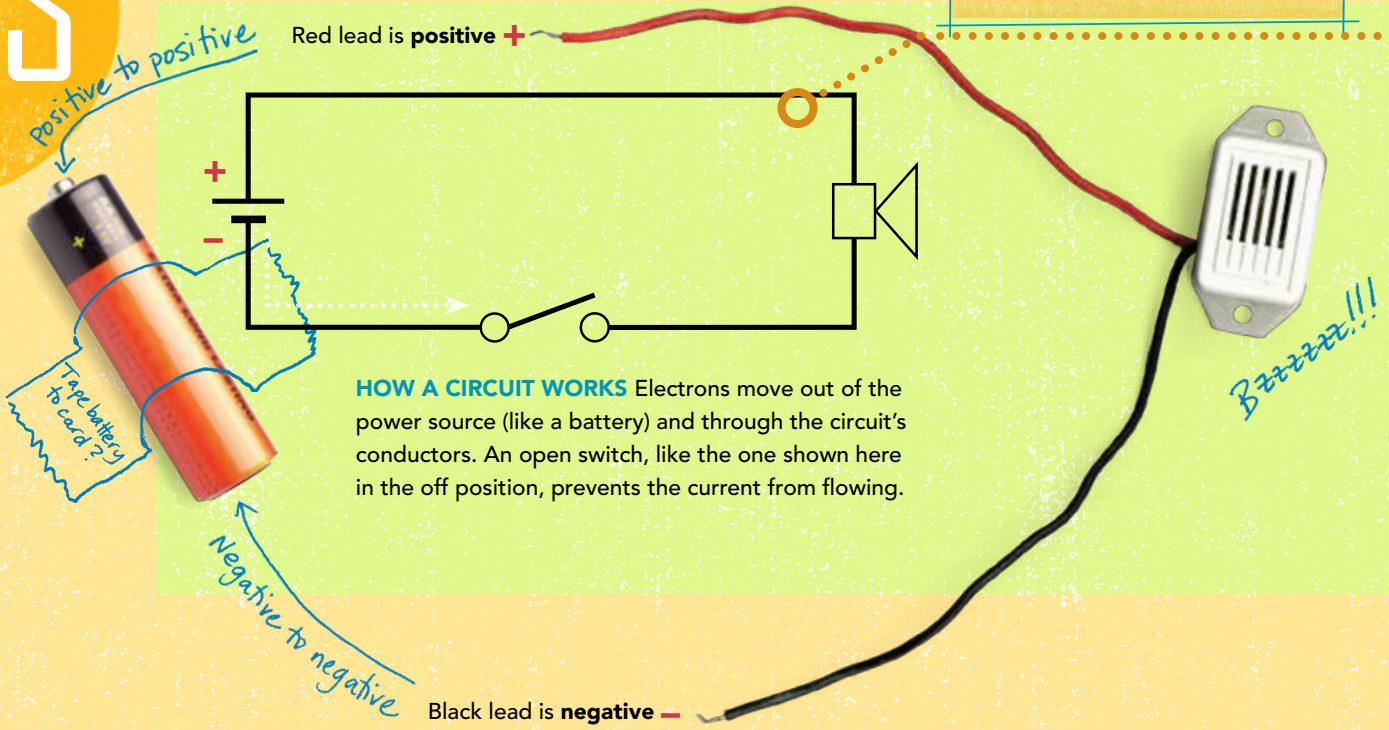
- Test the battery and buzzer to make sure they work. You might want to test some of your supplies to see which are good conductors.
- Figure out how to make secure connections between the battery and your conductors.

Materials

- 1 AA battery
- 2-3 wires with alligator clips
- Buzzer with positive and negative lead wires
- Aluminum foil
- Sheets of 8½" x 11" chipboard
- Office supplies: binder clips, paper clips, paper fasteners, rubber bands, tape
- Scissors
- Lab notebook and pen

You could also use any other materials you have around. Get creative! Improvise!

3



HOW A CIRCUIT WORKS Electrons move out of the power source (like a battery) and through the circuit's conductors. An open switch, like the one shown here in the off position, prevents the current from flowing.

Volunteer Instructions

ACTIVITY 2: SWITCH HITTER

ACTIVITY GOAL To engage girls in the creation of an electrical circuit using the engineering design process—specifically: teamwork, creativity, and troubleshooting

TIME Approximately 30 minutes

TEAMS Girls work in teams of four

SAY We can thank electrical engineers for the power systems we depend on every day—and for designing them and keeping them on. Think about turning a light switch on in a room. When that switch is on, a conductor inside allows an electrical charge to move through it and power the bulb. Today you'll be designing your own switches to power buzzers, which you can use for a game show if you decide to do one.

DO Invite girls to team up in groups of four, and remind them they'll need to create two different switch designs. Make sure girls have all their materials and invite groups to work in separate spaces.

Science to Share: SHORT CIRCUIT

You might insert this step between steps 2 and 3, if you have time.

Have the girls pass the Ping-Pong balls faster and faster. Eventually someone will drop one. Keep going until all the balls have been dropped. Ask: *What do you think just happened?*

Explain this was a bit like a short circuit: a defect in a circuit or wiring that causes electricity to flow along an unintended route—a shortcut—taking the path of least resistance. With less resistance, more current flows, which can cause wires to melt and lead to sparks, fires, and even explosions.

If the shortcut bypasses the load—in this case, the buzzer—it won't be activated. But often, we want to control when a load is activated. We can do so with a switch—which is what the next activity is about.

How to Motivate Teams

DO

- Ask teams questions about their progress.
- Create a positive and open atmosphere where questions are welcome.
- Encourage girls to assign roles for each person on their team.
- Let each girl know that she is a valued member of her team.
- Encourage the girls to inform one another about the steps, debate their meanings if needed, and come to a common understanding.

Volunteer Instructions

➡ Troubleshoot: Circuit and Switch Designs

ASK What available materials make good conductors?

HINT Connect a wire to foil and the whole piece of foil will act like a big wire.

How can you fasten conductors securely to the battery terminals?

HINT Use tape or rubber bands.

How can you design a switch so that it returns automatically to the off position after activation?

HINT Use folded chipboard as a spring to bring conductors together under pressure—it will separate when released.

How can you make the switch sturdy enough to keep solid connections during constant use?

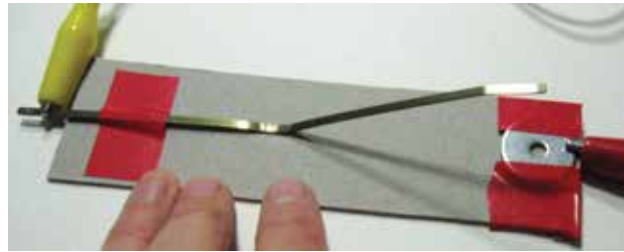
HINT Use more tape.

▶ **SAY** If a system doesn't work, keep trying. The engineering design process is centered on trial and error—and engineers work together to find the answer.

▶ **ASK** Did you assign one girl as leader or work equally to collaborate?

What was the most difficult part about putting together your switch?

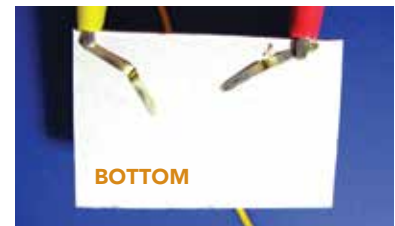
Will any of your problem-solving strategies help you troubleshoot in the next activity?



This switch uses a hairpin and washers, but perhaps a paper clip and coin could be substituted.



Paper clip switch
TOP

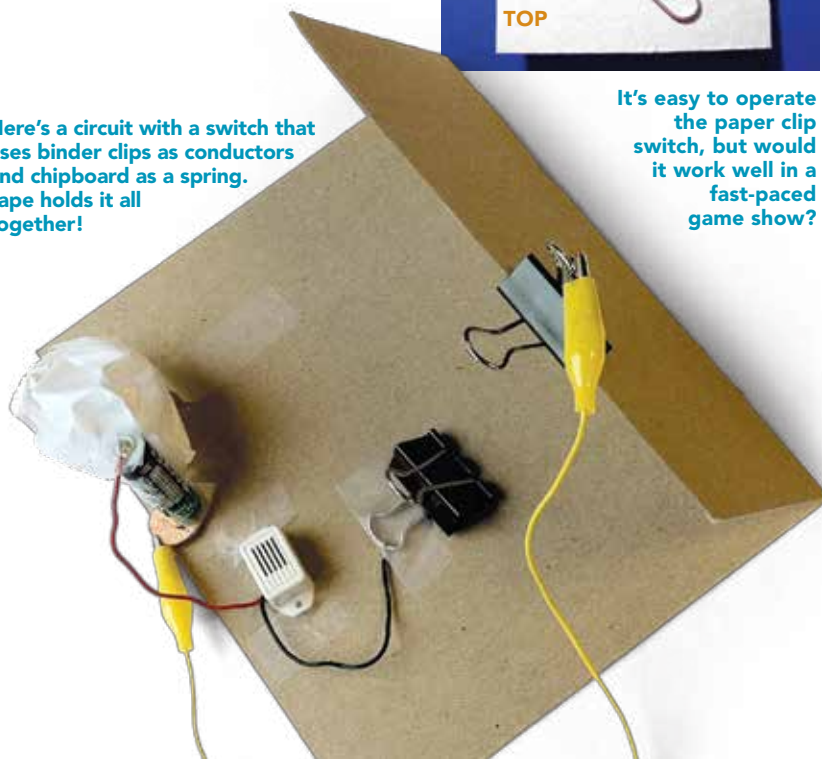


BOTTOM

It's easy to operate the paper clip switch, but would it work well in a fast-paced game show?



Here's a circuit with a switch that uses binder clips as conductors and chipboard as a spring. Tape holds it all together!



STEP 2: SWITCH BRAINSTORM!

Your team should create and test two different switch designs. You might want to brainstorm these questions before you begin building:

- Where will you locate the switch in your circuit?
- What action will operate the switch?

STEP 3: BUILD AND TEST

Build and test your two switches. They both have to work!

Consider:

- Does each one turn the buzzer on and off consistently?
- Is each switch sturdy enough to withstand constant use?

Troubleshooting Checklist

If a switch isn't working, ask yourself:

- Is the negative lead on the buzzer connected to the negative battery terminal, and the positive lead to the positive terminal?
- Are connections secure?
- Are the materials conducting electricity?

IMAGINE MORE

GAME SHOW You are a game show contestant...and a behind-the-scenes technician. Put your two buzzers to the test—and test your science knowledge too. Ask your volunteer to share the details about how you can do this.

Talking Electricity

CONDUCTOR A material through which current flows (such as wire)

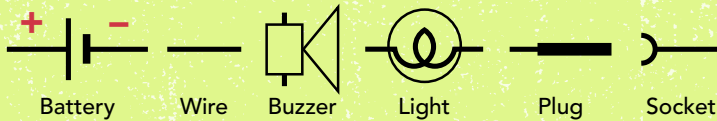
SWITCH Device that closes or opens a circuit (like a light switch)

BATTERY Batteries create a chemical reaction—making the energy needed for flow of the current from its negative end to its positive end.

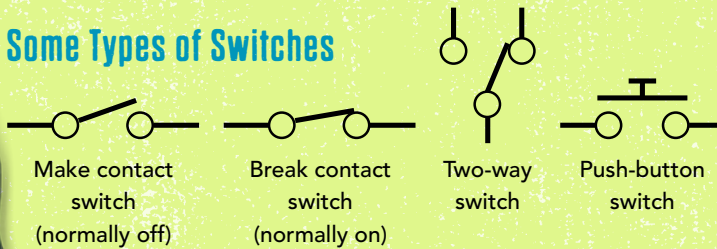
LOAD Device powered by electric charge, such as a light bulb or radio—or buzzer!

3

Some Circuit Symbols



Some Types of Switches



Load management is a big issue for power plants — if the load is too great, it causes a BLACK OUT!



IMAGINE MORE: GAME SHOW

ACTIVITY GOAL To demonstrate a fun use of circuits and give girls the opportunity to troubleshoot their designs

TIME Approximately 15 minutes

TEAMS Girls work in their teams from the “Switch Hitter” activity

Make sure to let girls know they can choose this optional activity if there is time and interest.

Game Show Brief

SAY *Your teams will use their buzzers to get the first opportunity to answer the questions. If your circuit or switch fails to work, you’ll troubleshoot with your team to keep things buzzing, so you can keep playing!*

STEP 1: GET READY, GET SET...

DO Invite girls to select one of them to be the game show host. She’ll read the questions and the answers aloud. Ask them to choose a judge. In a close call, she’ll decide which team’s buzzer goes off first. She’ll also keep track of the time the team has to answer—and keep the score, if you want to know who wins!

STEP 2: THE GAME QUESTIONS

- 1 The host reads each question aloud.
- 2 The first team to buzz gets five seconds to give their answer.
- 3 After they respond, the host reads out the correct answer.

STEP 3: PLAY AND REVIEW

DO Start the game. Don’t forget to tell girls to pause between rounds to swap out the switch on their circuit.

ASK *Which of your switch systems worked most consistently? Why do you think it did?*

What troubleshooting did your team have to do along the way?

Would you design your switches differently next time?

How did your team work together?

Scoring the Game

- The judge keeps score.
- Teams gain one point for each correct answer.
- Teams lose one point for each wrong answer.
- If two or more teams buzz at the exact same time, they both get to guess and can both gain (or lose!) points.
- The team with the most total points wins!

Make Leadership Connections

S DO “Sound Off: Thinking Outside the Box” (page 68 of *GIRLtopia* Adult Guide). Invite girls to consider how they view assertiveness as they brainstorm qualities that make “a nice girl” and “a leader.” Be sure to ask the reflection questions.

A DO “What’s Your Label?” (pages 70-71 of *BLISS* Adult Guide). Invite girls to think about the scientist they drew in Unit 1 and the labels they assigned to that picture. Get girls talking about how those labels—and ones they have for themselves—can help or hurt progress toward their dreams.



???

TRUE OF FALSE?

There are more species of dogs than there are species of bees.

ANSWER

False! While there are hundreds of different dog breeds, there is only one species of dog—the domestic dog, also known as *Canis lupus*. Bees, however, have more than 16,000 classified species!

???

TRUE OF FALSE?

A human baby has more bones than a human adult.

ANSWER

True! We are born with more than 300 bones, but as we mature these fuse into 206 total bones. The smallest bone is in your ear. Commonly called the stirrup bone, it averages only .3 centimeters in length—less than half the size of a raisin!

???

TRUE OF FALSE?

The number of living organisms on your skin is greater than the entire population of Earth.

ANSWER

True! Your body is made up of around 100 trillion cells, many of which are bacteria, viruses, and other microbes. In fact, your body contains more bacteria than it does human cells.

???

TRUE OF FALSE?

The air in our environment contains more oxygen than nitrogen.

ANSWER

False! While the most abundant gases are nitrogen and oxygen, nitrogen makes up around 78 percent of earth's atmosphere. Oxygen makes up 21 percent, while the remaining 1 percent includes argon, carbon dioxide, helium, and small amounts of other gases.

???

TRUE OF FALSE?

A billion pennies is worth more than a million quarters.

ANSWER

True! While a billion pennies would be worth \$10 million, a million quarters would only be worth \$250,000.

???

TRUE OF FALSE?

The population of China is approximately 40 times larger than the population of Canada.

ANSWER

True! In 2010, China's population was estimated to be 1,336,480,000, while Canada's population was close to 33 million. The only other country with a population of more than 1 billion citizens is India.

???

TRUE OF FALSE?

The Eiffel Tower in Paris is taller in summer than it is in winter.

ANSWER

True! The Eiffel Tower is made of iron, which expands slightly in hot weather. The tower can be as much as 15 centimeters taller in summer than in winter.

???

TRUE OF FALSE?

If every star in the Milky Way was a grain of sand, you'd have enough sand to fill an Olympic-size pool.

ANSWER

True! Astronomers estimate that there are between 200 billion to 400 billion stars within our galaxy, the Milky Way.

???

TRUE OF FALSE?

A pound of steel balls weighs more than a pound of rubber balls.

ANSWER

False! It's a trick question. They both weigh exactly the same: one pound.

???

TRUE OF FALSE?

You can only subtract the number 2 from the number 12 once.

ANSWER

True! Once you subtract 2 from 12, you can subtract 2 from 10, then 2 from 8, 2 from 6, 2 from 4, and 2 from 2.

???

TRUE OF FALSE?

If there's a 50 percent chance of rain on Saturday and on Sunday, there's a 100 percent chance of rain over the weekend.

ANSWER

False! Consider flipping a coin: Each time you flip, you have a 50 percent chance of getting tails. That, however, doesn't guarantee you'll get a tail every two times you flip.

???

TRUE OF FALSE?

You can estimate the temperature outside by mixing your math skills and a cricket's chirping.

ANSWER

True! How fast or how slow a cricket chirps depends on the temperature outside. To guess the temperature in degrees Fahrenheit, count the chirps you hear for 15 seconds, then add 37. The sum will approximate the temperature.

Materials

- CR2032 3-volt lithium battery
- Battery holder
- Felt (your color choices) or your own scarf, T-shirt, or cloth bag as a base for your circuit
- LED (light) with two bendable legs (maximum 3-volt usage)
- Snaps or fasteners (optional)

To share:

- Conductive thread (if thread is not available, use 24 gauge copper wire without a needle)
- Scissors, sewing needles
- Clear fabric glue
- Sewing or regular chalk
- Red permanent marker
- Needle threader or beeswax (optional)
- Needle-nose pliers (optional)

SOFT CIRCUIT TEXTILES

YOU ARE A TEXTILE ENGINEER. These scientists combine mechanical, computer, electrical, chemical, and structural engineering to develop fiber-based products, such as lightweight fibers for airplane wings or wearable technology—like blinking bracelets or solar-heated gloves.

Soft Circuit Brief

You will create a simple soft circuit that lights up by using conductive materials to connect a light and battery to fabric.

STEP 1: REVIEW

Soft circuit textiles, also known as electronic textiles (e-textiles), combine electronics—lights, batteries, switches, and sensors—with flexible materials, such as conductive thread and fabrics.

STEP 2: DESIGN


On a piece of paper, sketch the electrical connections (conductive thread) and placement of your components (LED light in front, battery pack on back).

- Do you want your electrical connection to zigzag or follow a decorative path? Where will your components go?
- Draw your circuit design with chalk on your felt or fabric.


STEP 3: COLOR AND CURL

- Color the longer (anode) leg of your LED red with a permanent marker to mark its polarity. By hand or using needle-nose pliers, curl the LED legs (wires) so that they can be sewn to your fabric.

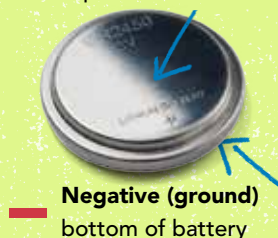
Identify Polarity

Positive (anode) 
leg of LED is longer

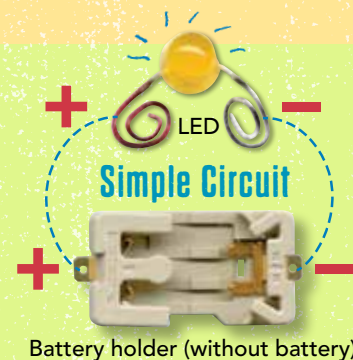


Negative (cathode) 
leg is shorter

+ **Positive (power)**
top and sides of battery



- **Negative (ground)**
bottom of battery



Battery holder (without battery)

Volunteer Instructions

ACTIVITY 3: SOFT CIRCUIT TEXTILES

ACTIVITY GOAL To get girls using engineering skills to develop a fiber-based product

TIME Approximately
30 minutes

TEAMS Girls work alone,
or in pairs if they prefer

SAY You are textile engineers designing a simple circuit onto fabric. Take a minute to look at the simple circuit schematic on page 30 of your girl books before you begin creating your component and designing your connection.

DO Invite girls to compare batteries and LEDs, and identify the anode and cathode.

SAY Batteries and LEDs have a positive and negative side. This is called polarity. Positive (+) is red and refers to power. Negative (-) is black and refers to ground. Remember that the power flows from the positive terminal of the battery, through components of a circuit (such as lights), and back to the negative terminal of the battery. In your LED, the negative, known as the cathode, is the shorter metal leg. The positive, longer wire is called the anode.



Materials: Soft Circuit Textiles

Per girl

- 1 LED (light)
- 1 CR2032 3-volt lithium battery
- 1 battery holder for CR2032
- Cloth, backpack, scarf, cloth hair tie, or T-shirt (optional)
- 2 sew-on snaps for switch (optional)

To share

- A selection of 9" x 12" felt squares in different colors (at least one per girl)
- Needle-nose pliers (optional) for coiling wire
- Needle threaders or beeswax
- Conductive thread (If thread is not available, use a 24-gauge copper wire without a needle.)
- Clear glue that works on fabric
- Sewing or regular chalk
- Sewing needles
- Red permanent marker

It's easier to sew with wire if you're only using one layer of fabric, as in this butterfly design (left).

Volunteer Instructions

Smart Wear

DO Get a discussion going about ways technology and engineering can make textiles fun and useful.

To help spark the conversation, offer these smart wear examples:

- Athletic head sweatband with built-in speakers
- Sneakers with a GPS tracker
- A T-shirt with a built-in keyboard
- Sensors on a cane for the blind
- Eyeglasses with closed captions for the deaf
- Rehabilitative vests for post-surgery patients

► **SAY** Keep your stitches as close together as possible to keep them in place whenever you bend or pull your fabric. If girls are using copper thread, suggest they only use one layer of felt and sew wider stitches.

► **SAY** A circuit is a continuous loop through which electricity travels. The power source here is your battery. Remember to make connections from positive to positive and negative to negative. Positive and negative should not touch or cross; this causes a short circuit.

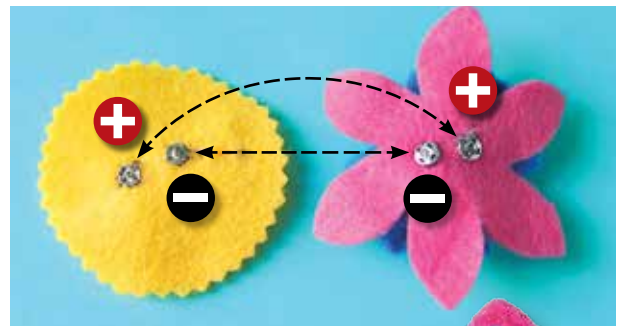
It's a Snap!

The switch below uses two snaps to complete a circuit. Unlike our other sample (opposite page), the conductive thread does not form part of the design. This two-snap switch helps keep the top and bottom pieces of the accessory together. To store, just fasten negative snaps to positives. This reverses the polarity so that the light stays off and the battery won't drain—as it would if you left the snaps unfastened.



Each terminal of the battery holder is stitched to a snap on the other side of the felt using conductive thread.

The LED is attached to the top of accessory. The coiled legs (hidden between layers of felt) are stitched to snaps with conductive thread.



To light the LED, fasten positive to positive snaps and negative to negative snaps. ► **TIP** You can mark the fabric to make it easier to tell positive and negative snaps apart.

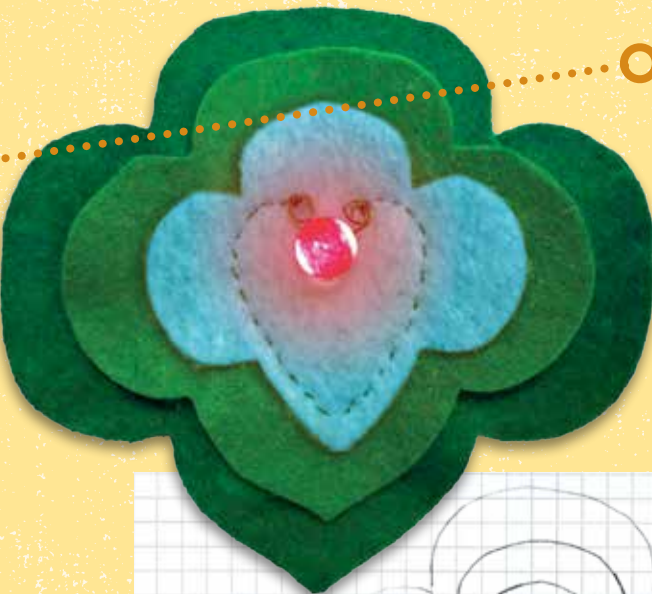


STEP 4: BEGIN SEWING!

- Follow your chalk pattern to sew the connections between components. Conductive thread frays easily, so you might use needle threaders to help thread your needle. Make sure to sew each component securely to the fabric before sewing between components. After sewing the connections, tie knots on the fabric's back side and cut the thread.

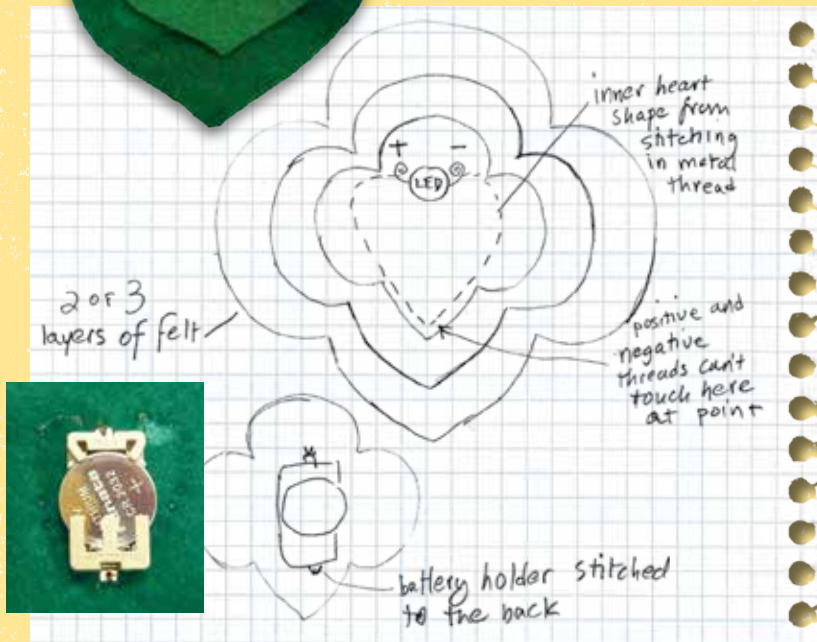
STEP 5: LIGHT UP!

- Insert the battery into the battery holder (with the "+" side facing up) and watch your design light up.



STITCH A SWITCH!

This simple circuit has no off-on mechanism. The only way to turn off the light is to pop the battery out of its holder. How could you build in a switch using a snap, hook and eye, or other stitchable fastener?



Troubleshooting Checklist

Circuit not functioning?

Ask yourself:

- Is the conductive thread frayed?
- Is the knot still in place? (Secure your knot by dabbing it with glue to also help insulate any loose thread ends.)
- Is the battery holder sewn in with the "+" right side up?
- Is the negative side of the holder sewn to the negative leg of the LED?
- Do positive or negative connections touch at any point?

IMAGINE MORE

BE A FABRIC TESTER Take a look at natural and synthetic fibers used in our clothes, homes, travel, and sports equipment to see how closely their properties match their needs and usage. Ask your volunteer to share the details about how you can do this.

Adapted from *A Soft Circuit Curriculum to Promote Technological Self-Efficacy* by Emily Marie Lovell © 2011 Massachusetts Institute of Technology (MIT). All rights reserved.



IMAGINE MORE: BE A FABRIC TESTER

ACTIVITY GOAL To compare fabric use with its properties

TIME 20–30 minutes

TEAMS Girls work in pairs

Make sure to let girls know they can choose this optional activity if there is time and interest.

Fabric Testing Brief

SAY You are a textile engineer, which means you combine chemistry, science, engineering, and technology to learn about fiber-based materials. Here you explore three ways to test fabric.

STEP 1: INSULATION

DO Invite each team to pour the hottest tap water into one plastic “control” bottle, record its temperature, and cap it. This control gives them a basis for comparison by showing how fast cooling happens without insulation. Next, have each team fill two bottles with hot tap water and record the water’s temperature before replacing caps. Ask teams to wrap a different fabric around the two bottles. After waiting 10 minutes, invite teams to record the water temperature in all three bottles, including their “control” bottle.

ASK Which fabric best insulated the water? What properties made the fabric better for insulation? How would this be useful in our lives?

STEP 2: WATER RESISTANCE

DO Invite teams to use 2" squares of different, labeled fabric. Soak each square in water for 10 seconds. Blot each square with a separate paper towel to see how much water comes off on the paper. Wait five minutes and blot again until paper comes up dry.

ASK Which fabric dried the fastest? What properties do you think makes this fabric more waterproof? How is this useful in our lives?

STEP 3: WEAR AND TEAR

DO Invite girls to use 6" squares of different, labeled fabric. Rub sandpaper across each square 10 times.

ASK Which fabric has the least number of fibers torn by the sandpaper? What properties do you think makes this fabric more durable? Where might you see durable fabrics used?

Test These Fibers!

Old dishtowels; T-shirts; discarded samples from a fabric store, such as cotton, fleece, flannel, polyester, linen, canvas, burlap, spandex, wool, vinyl, nylon, waterproof or indoor/outdoor fabrics



Insulated bottles (with “control” bottle on far left)

What We Wear

SAY Clothing is meant to keep us comfortable and protect us from the elements. Rash guards protect us from sunburn. Down-filled and nylon jackets protects us from rain, wind, and chill. Can you think of other ways clothes act as protection?

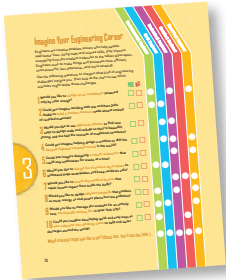
Sample responses

Clothing can protect us from...

- insects (bee masks, long sleeves)
- chemicals (hazmat suits)
- contact with abrasive substances (gloves while gardening, shoes while hiking)
- spreading disease (medical scrubs, face masks)

CLOSING CEREMONY: ENGINEERING CAREERS

STEP 1: DIG INTO CAREERS



DO Invite girls to look at the Unit 3 career checklist on page 37 of their *Imagine Your STEM Future* Girl Book.

SAY *You collaborated to design, create, and demonstrate your own electrical circuit. You solved problems and worked together to answer questions, the way engineers do. Check out some exciting careers that use these same skills.*

ASK Which of the “hot jobs” sounds most exciting?

What kinds of scientists could these engineers team up with to do their jobs?

Did anything surprise you about engineering?

Are there things engineers could improve in your neighborhood or school? What would you like to design to make your life easier?

STEP 2: MAKE LEADERSHIP CONNECTIONS

S DO “Create It’ Time” (page 47 of *GIRLtopia* Adult Guide) and invite girls to incorporate their “ideal vision” of women in STEM fields into their artistic *GIRLtopia* vision.



A DO “Dreams on a Wire” (page 56 of *BLISS* Adult Guide). Invite girls to discuss their feelings and dreams about STEM careers.

LOOK AHEAD Ask girls if they are interested in doing the next unit’s *Imagine More* activities so you can plan for materials.

Spark the Conversation

DO Point girls to a profile in Unit 3 of their *Imagine Your STEM Future* book and ask a targeted question. Example, page 34:

SAY *Heather Fleming’s advice is to always ask for help when you need it. How do you feel about asking for help with hard tasks, or when learning a new skill?*

Or choose a career checklist question as a group. Ask the girls what about the career sounds intriguing and why.

Remind girls to bring their Imagine book, Journey book, lab notebook, and pen to EVERY meeting!

Thought of the Day

Connecting with others is vital to leaders and scientists.

3

Imagine Saving the Planet

Unit 4 Overview

OPENING CEREMONY

What Environmental

Scientists Do Girls talk about environmental problems.

S "Catch the Dreams" Girls set up an ideal work group.

A "Putting Passion Busters in Their Place" Girls learn how to spot a passion buster.

ACTIVITY 1: ELECTRIC CONNECTION

Girls think of top five power sources.

ACTIVITY 2: OIL SPILL! Girls team up to solve a spill.

IMAGINE MORE: Girls remove oil from sand.

ACTIVITY 3: HERON'S FOUNTAIN

Girls build a simple fountain and explore the physics of hydraulics.

IMAGINE MORE: Girls investigate liquid's properties.

CLOSING CEREMONY

Imagine You! Girls explore careers that save the planet.

S "Ode to a Leader" Girls compose an appreciation for a female scientist role model.

A "Random Acts of Inspiration" Girls write an inspirational phrase about a science career.

SERIES CLOSING CEREMONY

Do this at the end of Unit 4 or hold for a separate session.

Prepare Ahead

DOING TWO SESSIONS? The planner on page 3 shows you how.

CLOSING CEREMONY Prepare Imagine Your STEM Future Certificates of Completion for girls. Check with your council about other STEM programs they have for girls and what school and community resources might help girls reach their goals.

OPENING CEREMONY

SAY Environmental scientists work on oil spill cleanups and search for alternative energy sources. Architects use hydraulic and pneumatic systems to create landscapes and buildings that use clean energy. In this unit, you'll be able to try out both of these green-minded roles.

ASK What solutions have you seen or heard about that can help eliminate environmental problems?

What kinds of science might have been involved in those solutions?

Make Leadership Connections

S DO "Catch the Dreams" (page 46 of *GIRLtopia* Adult Guide). On paper strips, invite girls to write the ideal qualities for a science team, then hang the strips on their dream catchers.

A DO "Putting Passion Busters in Their Place" (page 65 of *BLISS* Adult Guide). Add to reflection question: *Knowing what you do today, what would you say to others who believe science careers are mostly for men? That science is too hard? That it doesn't make a difference in the world?*

Unit 4 Materials

- **S** *GIRLtopia* (Girl Book and Adult Guide)
- **A** *BLISS: Live It! Give It!* (Girl Book and Adult Guide)
- Lab notebooks, pencils, pens, scissors, sticky notes
- Paper towels and garbage bags (for cleanup)
- Measuring cups and spoons
- Sugar (1 lb. bag, for Oil Spill and Viscous Drag)
- Water

KEY } **S** Grades 9–10
A Grades 11–12

ACTIVITY 1: ELECTRIC CONNECTION

ACTIVITY GOAL To get girls thinking about energy sources

TIME Approximately 15 minutes

TEAMS Girls work in teams of three (and stay in these teams throughout Unit 4)

STEP 1: RANK SOURCES

SAY *The electricity you rely on every day comes from a power station. But how does a power station get its power? In the United States, fuel comes from many different sources.*

DO Invite each group to write the top-five energy sources (from the chart at right) on separate sticky notes. Read them out of order so you don't give the rankings away! Have each team post their rankings on a wall or other space: the top being the source they think is most common in the United States, the bottom being the least common.

STEP 2: SHARE FINDINGS

DO Reveal the rankings by reading the clue (in chart) and by asking the girls to match the clue to the power source.

ASK *Were any of these rankings a surprise? Why?*

Which of these are clean energy sources? (Wind and water.)

Do you know what kind of energy source provides the power in your community?

ENERGY SOURCE	CLUE	RANK
Coal	A kind of rock that burns	#1 at 45.9%
Natural Gas	Found in a cow's intestines, but we drill for it underground	#2 at 22.0%
Uranium	A radioactive heavy metal, often used in nuclear reactors	#3 at 20.9%
Water	Enormous dams take advantage of this source of energy	#4 at 7.9%
Wind	Caused by differences in air pressure	#5 at 1.9%

For Oil Spill and Sand Cleanup

- Dispersants to share between teams: liquid dish detergent, shampoo, cola soda, salt water, and rubbing alcohol (use similar items for Viscous Drag, page 62)
- Empty plastic bottles to discard used oil, which might clog drains
- 1 can cocoa powder
- Vegetable oil

OPENING CEREMONY: "CATCH THE DREAMS"

- Yarn or thread, enough for each girl to create a web
- Push pins or tape

OIL SPILL!

Per team of three girls

- 2 aluminum roasting pans
- Clear plastic cup, at least 9 oz.

To share

- For skimming and containment: string, polyester batting, cotton balls, craft sticks, drinking straws, plastic teaspoons, plastic wrap, cut up pantyhose (optional)

IMAGINE MORE: SAND CLEANUP

Per team of three girls

- 2 cups sand

- 2 clear 16-oz plastic cups
- Filter funnel (two 2-liter empty soda bottles, cut in half)
- Paper towels, coffee filters, or napkins for filtering
- Cotton (optional)

HERON'S FOUNTAIN Materials on page 59

IMAGINE MORE: VISCOUS DRAG Materials on page 62

CLOSING CEREMONY Materials on page 64

4

Imagine Saving the Planet

OIL SPILL!

YOU ARE AN ENVIRONMENTAL SCIENTIST. What happens when an offshore oil rig explodes? When an underwater pipeline leaks? When an oil tanker sinks? In a typical year, more than one million gallons of petroleum spills into U.S. waters, and one major oil spill can double that number. Here, you'll be on a team of environmental scientists in charge of cleaning up a spill.

Cleanup Brief

Your team will compete to find the best system to contain and clean up an oil spill, using a variety of materials to simulate real methods.

STEP 1: OIL SPILL!

- Mix 1 cup oil with 2 teaspoons cocoa powder in a plastic cup to make "crude oil."
- Fill your "Oil Spill" pan ½ full of water.
- Dump the crude oil into the pan—that's your spill! Record your estimate of how much water is covered with oil.

Materials

- 1 cup vegetable oil
- 2 teaspoons cocoa powder
- Clear plastic cups
- Water
- 2 aluminum roasting pans (label one "Oil Spill" and the other "Cleanup")
- Scissors
- Paper towels for messes
- Various materials to use to clean up oil spills
- Lab notebook and pen

Some Cleanup Methods for Marine Oil Spills

Method	Advantages	Disadvantages	Test?
Containment Floating barriers called booms keep the oil slick in certain areas; skirts hang beneath the surface to assist in containing the oil	First stage of removal in many scenarios	Affected by wind, currents, and rough seas	
Skimming Vacuuming or skimming oil from the water; oil is then put in tanks on boats	May recover usable oil	Affected by rough seas; debris clogs skimmers	
Dispersion Breaking down large oil slicks into droplets by spraying detergents or other chemicals	Dispersing oil dilutes it in the water	Chemicals could harm marine life	
Absorption Soaking up oil with large sorbents sponges made of natural or synthetic materials	Useful where skimmers can't reach	Materials and oil have to be disposed of safely	
Bioremediation Adding fertilizers or microbes to speed up biodegradation (the natural process of microorganisms breaking oil into other substances)	Accelerates a natural process; most useful when oil is dispersed	Takes months to work, leaves residues	
Dredging Using a scooper or suction machine to remove oil that has sunk to the ocean floor; sand or silt can also be dredged up and used to create barrier "berms" to protect the shore	Necessary to recover oil below the surface	Disrupts ecosystems on the ocean floor	

Volunteer Instructions

ACTIVITY 2: OIL SPILL!

ACTIVITY GOAL Girls use problem solving and team building skills to design an oil spill

TIME Approximately 30 minutes

TEAMS Girls work in teams of three

SAY On April 20, 2010, an oil rig in the Gulf of Mexico exploded, creating the largest oil spill in U.S. history. Each day, 62,000 barrels of oil leaked into the ocean, roughly the same amount of oil consumed daily in Delaware. The faulty well was finally capped and sealed on July 15, but not before about 4.9 million barrels spilled into the water. Hundreds of scientists worked to find cleanup solutions. Be an environmental scientist and design your own cleanup system.

TIP If you don't have a measuring cup, mark a line on a plastic cup and have the girls measure with that. It's important that girls all "spill" the same amount of oil, so they all have the same challenge.

DO Remind girls to estimate and record the amount of water covered in oil after their spills so their cleanup efforts can be fairly evaluated. (It will likely be around 80 percent, depending on how they "spill" their "crude oil.")

DO Share some other uses for oil from Science to Share: OIL (at right) as girls are prepping their spill.

DO Remind girls to review this chart. Encourage them to consider these real-life cleanup methods. How they could use their materials to model some of these methods? If girls want to discuss advantages and disadvantages of each method, you might share from "Think About Scale" on page 54 to spark the discussion.

Science to Share: OIL

SAY You already know we depend on oil to fuel cars, trucks, planes, boats, and other vehicles. Can you think of some other uses for oil?

Sample responses "To make plastic for personal music players, rain jackets, and sandwich baggies."

"To make products that use a petroleum compound, such as toothpaste, shampoo, soap, nail polish, and deodorant."

Volunteer Instructions

Brainstorm Benefits

SAY *Scientists collaborate to get the best results from their collective brainpower.*

DO Make sure each team member knows the problem and goals.

Encourage everyone to participate.

Tell girls to build on one another's ideas.

Invite girls to be creative! Wild ideas can lead to great ideas.

Remind girls not to overlook the obvious—sometimes it's the best solution!

Let girls know that sketching or writing down ideas can be helpful.

DO Remind girls that there are many ways to work through the problem, so they can get creative. They also need to focus: They won't be testing their materials, so they have to make hypotheses about which materials will be most effective.

ASK *Will you begin with booms, skimmers, or sorbents?*

Which one will contain the spill?

In what order might your materials be most effective?

Could you create a boom? (from drinking straw or string)

Which materials absorb? (cotton balls, fiberfill)

Which skim? (spoon, craft stick)

Which materials disperse? (rubbing alcohol, dish soap)

DO Give girls a heads up when they have five minutes left—and when they're down to their last minute.

Think About Scale

ASK *Can you imagine miles and miles of an ocean spill? What might the equipment look like? How might it affect the environment?*

Sample responses *"Ships with special skimmers, which look like giant ladles from a soup pot."*

"Big floating booms that look like Styrofoam logs wrapped in plastic to contain an oil spill."

"Pounds of oil absorbent fibers in cotton or paper."

"Barrels and barrels of chemical dispersants."

DO Invite teams to walk around the room and evaluate one another's cleanup efforts.

ASK *How did you team's steps and materials differ from the other teams'?*

Did your team revise your plan as you went along? Why and how?

If you were to do the activity again, what would you change about your system?

What other materials do you think would have helped speed up your containment or cleanup?

Sample responses *"A sponge."
"Feathers."*

What if the oil reached the shoreline? What methods of cleanup can you imagine?

Sample responses *"Vacuum or pumping."
"Manual oil pickup."
"Cut the vegetation."*

STEP 2: DEVELOP YOUR SYSTEM

- With your team, decide how to use the available materials to clean up the spill. You don't need to use all of them.
- Consider the approaches listed in the table on the previous page as you plan. You might use more than one method.

STEP 3: CLEANUP!

When your volunteer gives the signal, begin your cleanup. You'll have 10 minutes!

- Use your chosen materials and techniques to remove as much oil as possible and put into your "Cleanup" pan.
- Record each step so you can compare results with your fellow environmental scientists! You'll want to be able to create the procedure for your system: this includes the overall approach, the specific step-by-step, and materials used in your cleanup.

STEP 4: CHECK OUT THE COMPETITION

- Explain your team's system to the group. Be sure to share your original estimate of the surface area covered in oil, so teams can evaluate your cleanup accurately.
- Evaluate and score each system, including your own team's.
- Discuss the winning team's system. *Why do you think it was so effective? Could it be replicated on a large scale? Is this system also the most cost effective? If so, why?*

Cleanup Scorecard

TEAMS	A	B	C	D
Oil removal				
Debris left after cleanup				
Total score (out of 6 possible points)				

RATINGS KEY

Oil Removal

- 0 No oil removed
- 1 About 25% of oil removed
- 2 About 50% of oil removed
- 3 About 75% of oil removed
- 4 Water is clean

Debris Left After Cleanup

- 0 Water has debris
- 2 Water has no debris

IMAGINE MORE

SAND CLEANUP Extracting oil from water is just part of the cleanup. Put some of your oil spill extraction know-how to work and see what cleans up oil on sandy beaches. Ask your volunteer for details about how you can do this activity.

Wild Ideas That Worked

Great solutions often come when scientists let their imaginations run wild. Just take a look at these three oil cleanup discoveries:

Human Hair Mats

Human hair, stuffed into tubes of nylon mesh, serve as improvised containment booms.

Oil-Eating Mushrooms

Mushrooms secrete acids and enzymes that break down pollutants.

Beeswax

Microscopic balls of beeswax contain bacteria that eat hydrocarbon compounds in crude oil.



IMAGINE MORE: SAND CLEANUP

ACTIVITY GOAL Girls will use teamwork and problem solving to find the most effective way to remove oil from sand

Make sure to let girls know they can choose this optional activity if there is time and interest.

TIME Approximately 30 minutes.

Suggest that girls do this activity in tandem with Oil Spill! to accommodate the wait time

TEAMS Girls work in same teams as Oil Spill!

STEP 1: CREATE THE PREP

SAY You know that pesky black stuff that gets on your feet when you walk on the beach? It's actually oil from ocean oil spills or from rocks like shale and limestone that naturally release petroleum. Wouldn't it be great to clean up sand? Find a way!

DO Invite girls to:

- Pour 1 cup of sand into each of 2 clear plastic cups. Suggest that girls can also create one "control cup" with 1 cup sand for the group.
- Mix 1 cup of oil with 2 teaspoons of cocoa powder in a separate cup to make "crude oil." (Same as in Oil Spill.) Pour ¼ cup crude oil into each test cup and the control cup, and mix thoroughly with the sand.
- Add a measured quantity of dispersant into the test cups (not the control cup). Girls might try cola, soda water, saltwater, rubbing alcohol, or dish soap. Stir gently and label each. Wait at least 10 minutes. While waiting, have girls build their funnel filters (next step).
- Girls should make 2 funnels per team (and 1 funnel for the group's control test). Cut soda bottles in half. The top half is where girls build the filter; the bottom half will hold the filtered liquid. Make a filter by placing the top half of soda bottle upside-down (like a funnel) inside the bottom half. Line the funnel with filter material, such as doubled-up paper towels or coffee filters.

Environmental Costs

Beaches and marshlands

Oil seeps into sand and pollutes habitats.

Sea birds Oil coats their feathers, making it impossible for them to fly or regulate their body temperatures.

Marine mammals Oil clogs the blowholes of whales and dolphins, coats the fur of sea otters and seals, and contaminates food supplies.

Food webs for fish and wildlife Oil diminishes generations of egg and larval organisms.

Marine ecosystems Oil destroys deep-sea coral, a natural habitat for marine life



STEP 2: RATE THE CLEANUP

DO Invite girls to:

- Observe the sand and dispersant mixture in their test cups.
ASK *Is there a separation of the two liquids? For example, are you seeing the sand on the bottom, dispersant in the middle, and oil on top?*
- Empty the sand mixture from each cup into a soda filter funnel. (Do the same with the control cup.) **TIP** Dispersant not filtering? Suggest that girls add water to the dispersant recipes. After about 20 minutes, invite girls to observe the sand to see how much oil residue remains. Suggest that they touch the sand to see how oily it feels. Have them ladle tablespoons of sand onto pieces of paper to compare how much residue each sample leaves. **ASK** *How effective was the dispersant in cleaning the sand? How much oil residue is left? Can you tell if the dispersant clung to the sand and created more contamination? How much oil was left in the control sample of sand without dispersant?*
- Come up with other ideas for ways to remove oil from sand. Refer girls to “Some Cleanup Methods for Marine Oil Spills” on page 38 of their *Imagine Your STEM Future* book. How could they apply these methods to miles and miles of beach?



We compared the dispersant properties of cola, dish detergent, and saltwater. This photo (near left) shows how much liquid seeped through the filters in 30 minutes. It's a good idea to label the cups and funnels!

Science to Share: CORAL

SAY Dispersants act as detergents, clustering around oil globs and allowing them to be carried away in the water. This improves the surface and mobilizes the oil. Smaller oil droplets, scattered by currents, may cause less harm and may degrade more easily. But research has found that the dispersed oil droplets infiltrate into deeper water and can contaminate coral. Coral is one of our richest marine ecosystems, home to 25 percent of the animals and plants that live in the ocean.



4

HERON'S FOUNTAIN

YOU ARE AN ENVIRONMENTAL ARCHITECT. Heron of Alexandria was a brilliant engineer and inventor (born circa 10 CE). He invented many ingenious devices, including this fountain, which works without a pump. It is powered by clean energy: gravity plus air and liquid pressure. Environmental architects are always on the lookout for ways to use clean energy in their buildings and landscapes—they might design a fountain for a park or garden using the same principles Heron did here.

Build a Fountain Brief

Using Heron's design, you and your team will build a fountain to see how different forces work together to lift liquid.

STEP 1: PLAN AND PREP

- Collect materials and review the diagram on the next page.
- Cut the empty bottle in half with scissors. Use the top half, upside down, as your **fountain**.
- Pour about 2 cups of water into the bottom half of the empty bottle. Add food coloring (one color of your choice) and set aside.
- Add water to one empty plastic bottle so it is 10 percent full. This is your **air supply bottle**.
- Add water to another empty bottle so it is 90 percent full. This is your **liquid supply bottle**.

STEP 2: BUILD YOUR FOUNTAIN

- Cut two pieces of tubing about 44 inches long and a third about 32 inches.
- Following the diagram, thread tubes through the holes in your rubber stoppers.
- Insert the stoppers firmly into the bottles and fountain to make your system airtight.

STEP 3: ADD WATER

- Hold the fountain *above* the air and liquid supply bottles. Pour the colored water you set aside into the fountain to start it flowing.

Materials

- Scissors
- 4 empty plastic soda bottles (1 or 2 liters in size)
- Food coloring
- 3 rubber stoppers
- 10-foot length of aquarium tubing
- Tap water to fill plastic bottles

You can make a hole in the empty bottle by squashing it and cutting through both sides at once. Then poke your scissors through the hole and cut all the way around.

It can be hard to get a tube through a hole in the rubber stopper. It helps to cut the tip of the tube diagonally and put a few drops of liquid soap in the stopper hole. Rinse off the soap after threading the tubes.

Volunteer Instructions

ACTIVITY 3: HERON'S FOUNTAIN

ACTIVITY GOAL To get girls using creativity, teamwork, and problem-solving skills to build a simple hydraulics machine

TIME Approximately 30 minutes

TEAMS Girls work in teams of three

◀ **SAY** *Heron, an inventor in ancient Greece, applied his knowledge of mathematics and physics to design a fountain that doesn't use a pump. Instead, he relied on the properties of liquid and air. As an environmental architect, you'll build a model of Heron's fountain and explore what kinds of clean energy make it work.*

◀ **SAY** *This experiment isn't difficult, but it's important to set it up correctly! Of course, mistakes are all part of the process.*

◀ **SAY** *Make sure each team picks a different color for the water in your experiments. This way you can see the liquids moving through the tubes and the colors mixing in the air supply bottle.*

Materials: Heron's Fountain

Per team of three girls

- 3 two-hole #3 rubber stoppers
- 10-foot length of aquarium tubing that fits rubber stoppers
- 3 clear plastic soda bottles (1 or 2 liters), standard shape to fit rubber stoppers

To share

- Food coloring, two or more bright colors

Science to Share: TEAM BUILDING

DO Remind girls that successful scientists learn how to work together—and that different opinions often lead to combined ideas and the best outcomes.

SAY *Scientists worldwide want to know what disaster wiped out 90 percent of life on Earth 250 million years ago. But separate labs have been producing different results. So they joined forces with the National Science Foundation to create one set of measuring standards to find an accurate chronology of Earth's past. (If girls have access to a computer, they can check it out at earth-time.org.)*

ASK *Is everyone aware of the goal?*

Are you sharing ideas?

Are you testing ideas and coming up with solutions?

Volunteer Instructions

▶ **DO** As girls add liquid and get their fountains working, get them talking about what they think is happening and how. Then share information from “How It Works” (below). Encourage them to see what happens when they change the height of the different bottles.

▶ **TIP** Ask girls to figure out how to restart the fountain when it stops flowing. They could swap bottles, or empty and refill both air and liquid supply bottles as they did in initial setup.

▶ **ASK** *Is Heron’s fountain a perpetual motion device, meaning one that can keep running forever?*

What other questions did this experiment bring up for you?

Sample responses *“Where does water in the tap come from?” “How does it get into our pipes?”*

How do most fountains work?

Sample responses *“Modern fountains might be run with a pump.” “Laying water pipes or building aqueducts that slope gradually downward over long distances can harness gravitational kinetic energy.”*

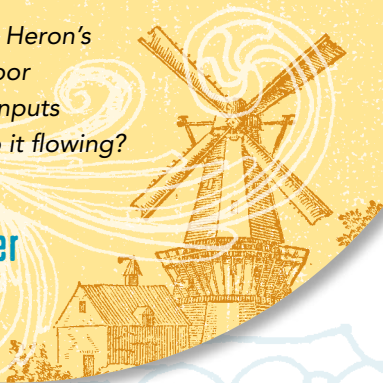
Inset from page 42 of the Girl Book

STEP 4: ANALYZE IT!

- Once you have your fountain working successfully, time how long it flows. *Why does the liquid stop flowing? How might you change the fountain design to make it flow longer or to restart it every time it stops?*
- See if you can change the rate of flow by changing the position of the bottles. *How does it change and why?*
- *What role does gravity play in your fountain? How about air and liquid pressure?*
- *How might you scale up Heron’s design to build an outdoor fountain? What energy inputs would you need to keep it flowing?*

Energy from Air and Water

...have been extracting
...wind and
...more than



Science to Share: HOW IT WORKS

The water in the fountain contains gravitational potential energy, and as it falls downward, it creates pneumatic pressure in the air supply bottle. This forces air through the tube into the liquid supply bottle, which in turn pushes the water through the tube into the fountain. When the liquid supply bottle is empty, the fountain stops.

FOUNTAIN

Insert the stopper from inside the fountain.

The tube from the liquid supply should stick up 4"-5". The tube to the air supply bottle should stick up 1".



This tube should be about 32" long.



These two tubes should each be about 44" long.

LIQUID SUPPLY BOTTLE

Position on a table.

The tube to the air supply should only stick down about 1". The tube to the fountain should reach the bottom of the bottle.

AIR SUPPLY BOTTLE

Position on the floor.

Both tubes should extend about 1" below the stopper.

Feeling the Pressure

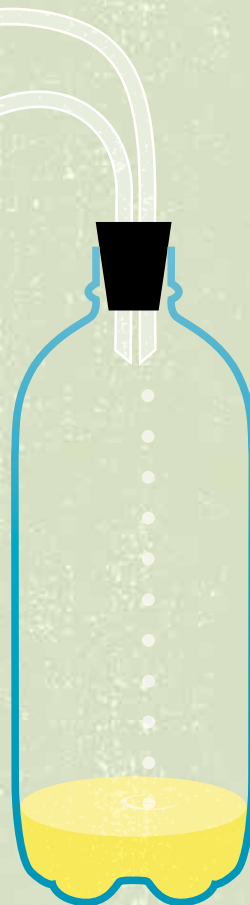
Heron's fountain is both a hydraulic and pneumatic system. These systems have many common uses.

HYDRAULIC SYSTEMS use liquids under pressure in confined spaces

- to lift blades on snowplows
- to operate carnival rides
- to raise and lower airplane landing gear

PNEUMATIC SYSTEMS use gases under pressure

- for braking systems on trucks
- to sound air horns on ships
- to keep aircraft cabins at near sea-level pressure



Tip: This book is 11 inches high, so you can use it to measure your tubes before cutting!



IMAGINE MORE: VISCIOUS DRAG

ACTIVITY GOAL Girls try out fluid mechanics as they test viscosity in liquid

TIME Approximately 20 minutes

TEAMS Girls work in teams of three

Make sure to let girls know they can choose this optional activity if there is time and interest.

VISCIOUS BRIEF Some fluids such as honey and ketchup are thick, flow slowly, and have high viscosity. This means they have high internal friction between their atoms. “Elasticity” describes the flexibility or stickiness of a substance, while “viscosity” describes the thickness or resistance to flow. Different liquids have different properties. Here, you will test viscosity by dropping a marble into different types of liquids.

STEP 1: PREPARE TEST BOTTLES

DO Invite the group to create one “control” bottle. Pour water into a bottle, drop a marble into the liquid, and use a stopwatch to time how long it takes for a marble to drop to the bottom.

(HINT) The marble will probably drop too fast to time and that’s okay.) Next, have each team pour a different liquid into each of their two bottles. This can be whatever mixture they choose.

►TIP Encourage girls to use higher viscosity liquids, like syrup and hand sanitizer. Make sure they use a sticky note to label the ingredients for each bottle. (For example, girls might pour 1/8 cup salt into 1 cup of water, or mix soda and corn syrup.)

STEP 2: MAKE THE DROP!

DO Have the teams time the marble drop in each of their liquids and record the results in their lab notebooks. Invite girls to seal the caps on their bottles, turn them upside down, and re-time their drops. Girls might also try warming the liquids by running hot tap water over the test bottles. (For safety, please do not boil or microwave liquids.)

ASK *Of all the liquids tested, which were the most viscous? Did you find that heating the liquid increased or decreased its viscosity? Can you think of reasons why scientists study viscosity?*

Sample response *“To understand blood flow, lava in volcanoes, and ocean currents.”*

Materials: Viscous Drag

Per team of three girls

- Stopwatch
- Empty 8 oz. water bottles
- 12 marbles to fit bottle neck

To share

- Water, corn syrup (clear enough to see through), and other clear liquids to experiment with: vegetable oil, clear soda, shampoo or liquid soap, hand sanitizer
- Salt to add to water

Science to Share: VISCOSITY

Viscosity is the thickness or resistance to flow of a liquid.

Fluids with lower viscosity are referred to as thin liquids and those with higher viscosity as thick liquids. Friction between the molecules in a liquid causes viscosity.

ASK *What’s an example of a low-viscosity fluid? How about air? Or water?*

Fluids with high viscosity flow more slowly and are harder to move through. *Can you name some? How about honey? Shampoo?*

CLOSING CEREMONY: ENVIRONMENTAL CAREERS

STEP 1: DIG INTO CAREERS



DO Invite girls to turn to the Unit 4 career checklist on page 47 of their *Imagine Your STEM Future Girl Book*.

SAY *You used your imagination, teamwork, and problem-solving skills to clean up an oil spill and build Heron's fountain. Take a couple of minutes to explore jobs that use these skills to protect and preserve our environment.*

ASK *What environmental issues are important to you?*

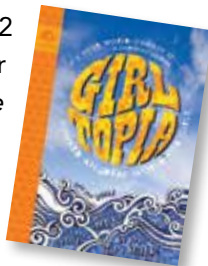
Which of these careers might help you improve those issues?

What interests you most in the natural world? Trees, oceans, endangered species?

In which of these careers could you work with that part of nature?

STEP 2: MAKE LEADERSHIP CONNECTIONS

S DO Invite girls to do "Ode to a Leader" (page 32 of *GIRLtopia Girl Book*), but ask them to direct their letters to a female scientist profiled in their *Imagine Your STEM Future Girl Book* who inspired them. Or they can write to a scientist they know or admire.



A DO "Random Acts of Inspiration" (page 57 of your *BLISS Adult Guide*), but invite girls to write an inspirational word or phrase about science careers. Examples:

"Scientists change the world."

"Flavor chemists get paid to create ice cream flavors."

Spark the Conversation

DO Point girls to a "Real World Profile" in Unit 4 of their *Imagine Your STEM Future* book and ask a targeted question. Example, page 43:

SAY *Tanya Martinez was inspired to take environmental action by her grandfather. Who in your family or community inspires you to make the world a better place?*

Or choose a career checklist question and answer it as a group! Ask the girls what about the career sounds intriguing and why.

Thought of the Day

Great scientists are also great leaders—they share the goal of making the world a better place.

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SERIES CLOSING CEREMONY

STEP 1: FUTUREPAGE

DO Invite girls to turn to the FUTUREPage (page 48) of their *Imagine Your STEM Future* Girl Book and fill out the profile. Be sure to point out that this is something they can also share with a mentor as they continue to imagine their future. To get them started, you might ask:

- Before this series, how would you have described science careers? What will you tell your friends about them now?
- What challenges will the world face in the next 15 years? How could your career in science help make a difference?

STEP 2: SHARE YOUR FUTURE!

DO Have girls look at “Reaching Your Future” on page 17 of their *Imagine Your STEM Future* Girl Book.

ASK What do you consider the most helpful and important advice from the list? Why?

What personal dreams do you think a science career can help you achieve?

DO Point out “Resources” (page 49) in their *Imagine Your STEM Future* Girl Book.

TIP In this step, share council and community resources that can help girls reach their post-Imagine goals!

STEP 3: EVALUATION

If you plan on doing an end-of-series evaluation, now would be a good time. Allow 10–15 minutes for girls to fill them out. Collect them before moving to the next step.

STEP 4: IMAGINE CERTIFICATES

SAY You are curious, creative, and not afraid to push boundaries. Much of what you experienced in *Imagine* will build foundations for your future—in science, and in your life. We hope you carry your inspiration forward, and help the world meet the growing need for skilled scientists through realizing your own dreams. Let this Certificate of Completion be a reminder of that.

DO Suggest that girls take turns presenting Imagine certificates to one another and ask each to say something special about another’s contribution to the group and series.

NOTE You can do this at the end of Unit 4, or if you are breaking into two sessions, hold this to close your final meeting.

Materials: Closing Ceremony

- Post-session evaluation forms, if provided
- Imagine Your STEM Future Certificates of Completion (download at forgirls.girlscouts.org/imagine)

Make Leadership Connections for Awards

When girls go on a Girl Scout Leadership Journey, they have a chance to earn prestigious awards and their *Imagine Your STEM Future* experience can help! Here’s how:

S GIRLTOPIA VISIONARY AWARD



SAY You can earn the Visionary award by helping girls and women in your community. You might start by swapping ideas with some local scientists about what needs improvement.



A BLISS DREAM MAKER AWARD

SAY You can earn the Dream Maker award by helping someone else start achieving a dream. The first step is to find some successful dreamers—maybe you could interview a scientist.