YOUR STEM FUTURE

girl scouts

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Wanted: *You!*

Imagine having a career that lets you be creative, active, and well paid—*and* change the world for the better. Science, technology, engineering, and math (STEM) skills can help you get there!

Take a look at some of the many in-demand careers right now and what you might do:

- **Materials Scientist** Make artificial, electronic superskin powered by solar cells for use in clothing, robots, and prosthetic limbs.
- **Renewable Energy Engineer** Work in an ocean-side lab finding new ways to turn waves into clean energy.
- **Landscape Architect** Design new public parks in old, unused spaces—like in an abandoned shipyard or an old elevated subway line.
- **Video Game Developer** Create alternative universes that can show people how to better treat the planet.

Even with these exciting job prospects, women, who make up almost half of our country's workforce, hold only 25 percent of math and computer science jobs and 11 percent of engineering jobs. That can change with you—right now.

The Goal of Imagine Your STEM Future

To help you discover which science careers you find most exciting.

You'll try out some of the great jobs in science, technology, engineering, and math: You'll be an electrical engineer, a food scientist, a forensic scientist, and a whole lot more.

So get ready to uncover some new passions—or figure out practical ways to use the passions you already have. *Imagine Your STEM Future* is a perfect place to get inspired and start imagining the amazing possibilities for your future.

What Do You Mean by *Science*?

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

Series Overview

Unit 1: Imagine Yourself on the Cutting Edge

Notice the science in everyday stuff—like what's in your backpack. Then design a future product and try out a bit of computer programming (without a computer). **Imagine More activities** Build a future city, and play cards to create a computer algorithm.

Unit 2: Imagine Yourself in a Lab

As a forensic scientist, you'll extract DNA from a banana. Then try out being a food scientist by creating your own vinaigrette and taste testing against the group's recipes. **Imagine More activities** Extract your own DNA, and test for gluten in flour.

Unit 3: Imagine Yourself as an Engineer

You'll be an electrical engineer as you team up to build a switch-activated circuit. Then use your engineering skills and make fabric that lights up. **Imagine More activities** Play a science trivia quiz game, and find out what it takes to test fabric's properties.

Unit 4: Imagine Saving the Planet

Be an environmental scientist as you clean up an oil spill—the team that removes the most oil in 10 minutes wins! Then, as an environmental architect, build a simple fountain and consider how air and water can make clean energy. **Imagine More activities** Clean oil from sand, and try fun ways to test viscosity in liquid.

Careers!

You'll delve into salaries and job descriptions about in-demand careers and read about real-life women scientists who have these jobs. Then you'll fill out a questionnaire after each unit to find out what kind of scientist you might like to be!

FUTUREpage

Have some fun as you profile yourself in 15 years—and finish the series with a record of all your dreams for your future in science.

IMAGINE MORE

In each unit, you will find Imagine More boxes that offer more activities you can do if you have the time and interest. Just ask your volunteer to share the details about how you can do them.

Working Out of the Box

You'll notice that science careers often fit into more than one box! An electrical engineer might program computer circuitry (systems architecture), design solar panels (product design), or create a robot for the operating room (biomedical science). That's one of the reasons a science career is so exciting. There are so many ways to use your skills!

Welcome to Girl Scouts

Girl Scouting is a century-strong sisterhood with a tradition of helping girls like you become leaders who change the world. Astronauts like Mae Jemison, CEOs like Martha Stewart, Secretaries of State like Hillary Clinton, and star athletes like Venus Williams were all Girl Scouts. By taking part in this series, you become part of a movement with girls in every corner of the world, a movement that is 10 million girls strong.

National Leadership Journeys

The heart of Girl Scouting is an experience called a Leadership Journey. Each Journey starts with a theme, like the environment or advocacy, and gives you the opportunity to unite with girls across the country to make the world a better place—together.

Although you will not be doing a whole Journey during this series, you'll be able to make some important connections between a Journey and the fun you're having with STEM this way:

GIRLtopia If you're in 9th or 10th grade (called a Girl Scout Senior), you'll imagine a perfect world for girls. Leaders and scientists, after all, are visionaries!

BLISS: Live It! Give It! If you're in 11th or 12th grade (called a Girl Scout Ambassador), you'll dream big, now and for the future—and inspire others to dream big too—just like scientists do.

What's a Journey?
Journeys are adventures that invite you to explore what it means to be a leader in your life and in the world.

Leadership and Science

It's always exciting to challenge yourself by doing new things you've never done before! The Girl Scouts' Imagine Your STEM Future series is filled with lots of fun activities, interesting profiles of female scientists, and fantastic experiments. You'll discover things about yourself you never knew, connect with brand-new friends, and become resourceful at solving problems as you do the series. Here's how:

DISCOVER SELF You'll find out who you are, what you value, and what interests you. You might discover how science can help the things you care about, like protecting the planet, finding a cure for disease, or inventing the next great technology.

CONNECT You'll make new friends. It's always fun to connect with other girls as you team up and create a network of friends to help others. As you do the hands-on activities, you'll learn how scientists work together in teams to explore ways to make a difference.

TAKE ACTION You'll find out how you can lead the way—and make the world a better place. You'll learn about scientists who make an impact in the world by finding solutions to problems.

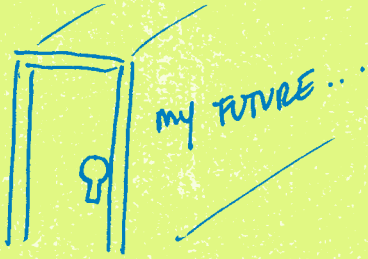
It's Up to You!

Of course, the magic, fun, and friendship of Girl Scouting happens not just in what you do but in how you do things.

You get to decide what activities to do, how to do them, and why it matters to you. In *Imagine Your STEM Future*, you'll have some instructions to start you off, then the rest is up to you. In Girl Scouts, we make things as girl-led as possible.

You'll team up to do activities and work through problems with other girls as fellow scientists. You can draw upon their ideas and creativity when you need it—just as they'll draw upon yours.

Your activities are all hands-on, and you will see how what you discover fits into your life today and in the future—and then use your new knowledge in the world around you.



If you're inspired and want more, talk to your volunteer about how to continue imagining all the ways you can change the world in Girl Scouting!

1 Imagine Yourself on the Cutting Edge

DESIGN THE FUTURE

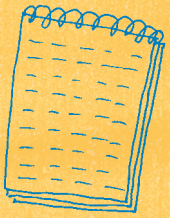
YOU ARE A PRODUCT DESIGNER. That means that when you look at all the items around you—from your phone to your bag to your chair—you're thinking about how they work and how they could work better.

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?

Materials

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



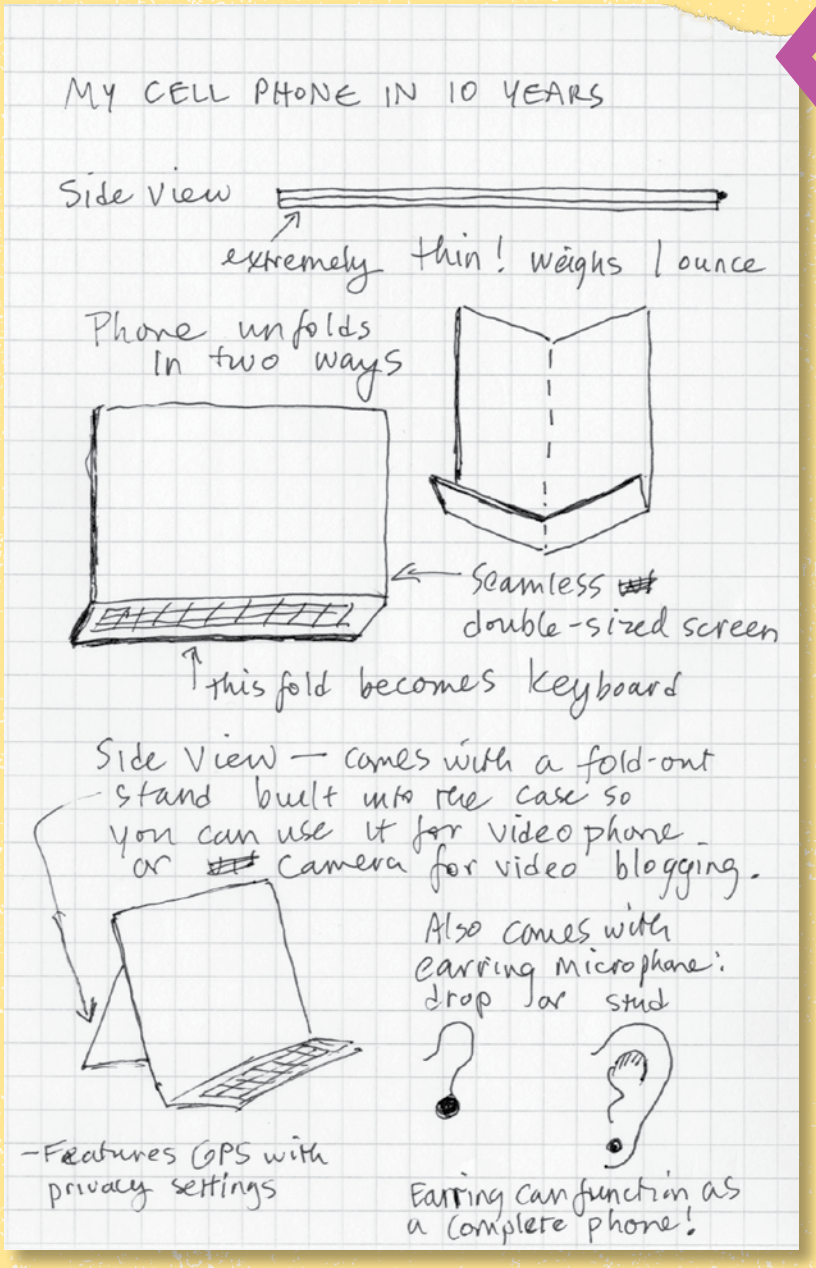
STEP 1: ASK THE BIG QUESTIONS

	NOW	IN 10 YEARS
What is it?		
Who uses it?		
What does it do?		
What could it do better?		

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.



Inspired? Now imagine your product in 50 years.

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.

1

SORT YOURSELF!

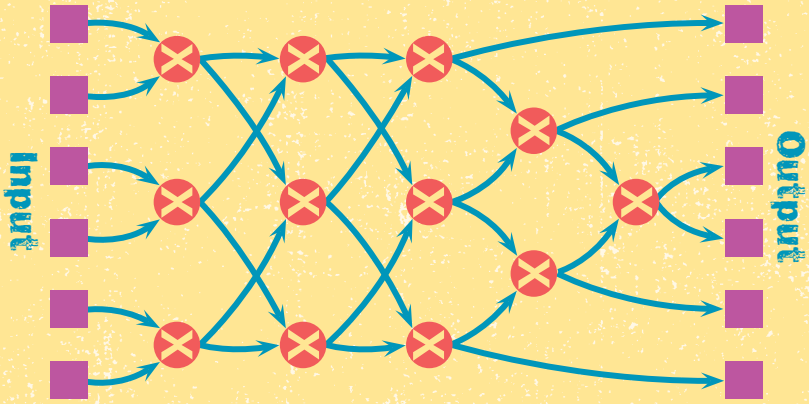
YOU ARE A COMPUTER SCIENTIST. Computer scientists come up with creative algorithms that tell computers how to sort and process huge amounts of information efficiently.

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

- 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

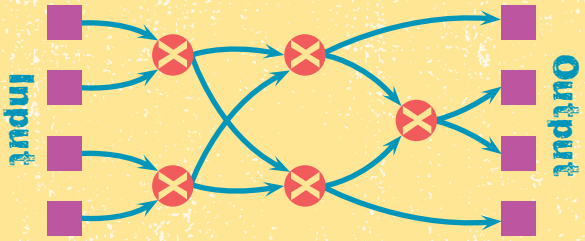
- Try it backward! *What happens when you move backward on the network from output to input?*
- Change the order! Have the girl with the smaller number go right instead of left. *What's the output now?*
- Use words! Write any word on a sticky note, and team up to use your network to end up in alphabetical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

STEP 5: NETWORK SHOWDOWN

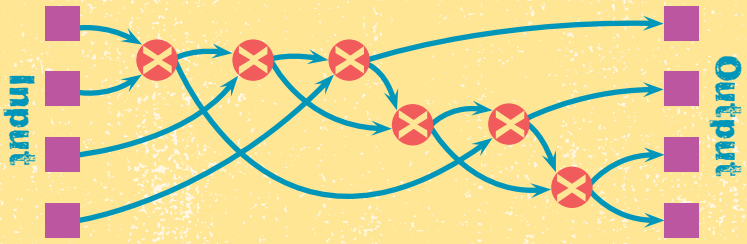
The diagrams below show two different networks that will sort four inputs. Using painter's tape or chalk, one team should make network A, while the other team makes network B.

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

A

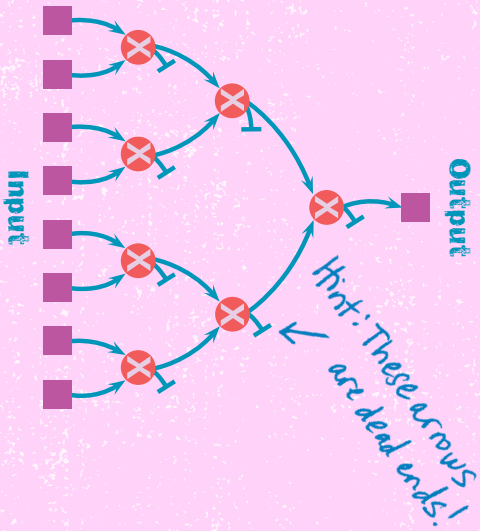


B



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.

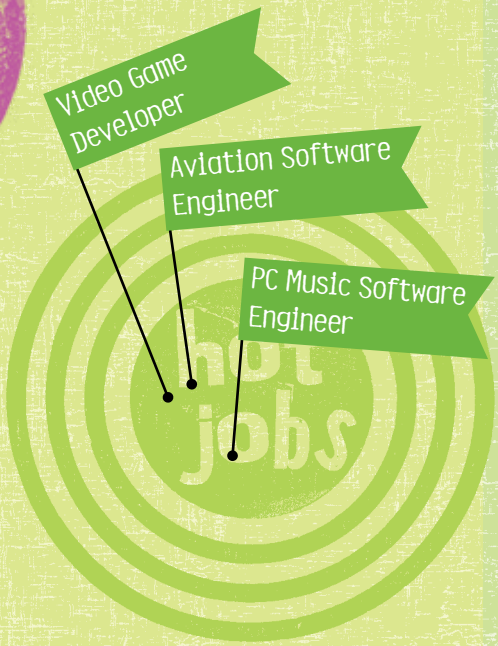
Imagine Your Cutting Edge Career

1

SOFTWARE ENGINEER

Average Annual Salary

Starting $60,000
Experienced $90,000



Every time you play a video game, send a text message, or order something online, you're using the work of a software engineer. From apps to modern automobiles, software engineers design and maintain the programs that make technology work. It's no surprise that the demand for software engineers is sky-high!

As a software engineer, you could make the world a better place by…

- Programming apps for mobile phones that let families chat with far-away relatives using high-definition video.
- Designing video games that simulate real-world situations like oil shortages or hurricane cleanup so solutions can be found before the problems occur.
- Creating a computer program that could trace hackers back to the source to help stop cyber crimes.
- Designing the programs that will make the movie experience 4-D: software that makes seats vibrate and release mist, "breeze," and fragrance effects synced to on-screen action.

Courtesy Shaundra Daily

R U Having a Bad Day?

Name Shaundra Daily
Job Assistant Professor, Clemson University, School of Computing
She makes the world a better place by developing software that helps people explore their emotions.

Shaundra Daily graduated from the Massachusetts Institute of Technology Media Lab and works in a field called affective computing. She writes programs to help people understand their feelings about difficult situations. In one of her projects, girls type in stories about what they're going through, and the program turns them into a digital comic book. "The software reads each caption and tries to determine, sort of like a real person would, what emotion is being expressed," Shaundra says. The program then starts a conversation with the girl so she can dig deeper into her emotions. Shaundra grew up in Alabama and wanted to work for the FBI before she found her passion working with feelings and technology. "Being a professor and conducting research means that I find evidence to try and solve puzzles all the time. Similar work, different context!"

Boston University Photography

Average Annual Salary

Starting $60,000
Experienced $95,000

MATHEMATICIAN

Wall Street employs mathematicians to predict stock market trends. Biomathematicians use high-powered computer databases to find and explore patterns in the human genome. NASA needs mathematicians to model rocket trajectories. In short, great math skills add up to a long list of career opportunities.

As a mathematician, you could make the world a better place by…

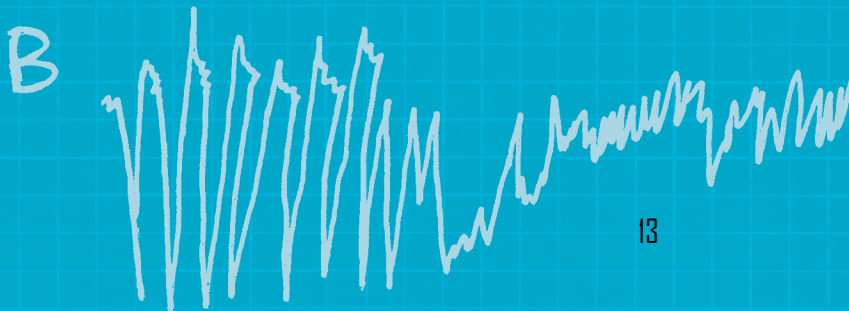
- Designing test procedures for car parts—and figuring out how long they can safely be used.
- Helping insurance companies estimate the likelihood of future events like earthquakes and floods so they can provide the best policies for the lowest cost.
- Modeling the spread of forest fires depending on weather, ground cover, and type of trees so firefighters can save more homes, humans, and animals.
- Showing airlines how to use smarter scheduling to reduce costs of aircraft parking, engine maintenance, and air pollution.

This Is Your Brain on Math

Name Nancy Jane Kopell

Job Director, Cognitive Rhythms Collaborative; William Fairfield Warren Distinguished Professor at Boston University
She makes the world a better place by using math to answer questions about how we think.

Nancy Jane Kopell is a biomathematician, which means she uses math to answer questions about biology. She studies rhythms in the brain and applies math patterns to find out what happens when we do simple movements like walking, swimming, and breathing. Nancy's work helps to explain symptoms for schizophrenia and Parkinson's disease, as well as how anesthesia works.



1

Average Annual Salary

Starting $60,000
Experienced $85,000

PRODUCT DESIGNER

From building better toasters to designing the next generation of smartphones, product designers improve items we already use and design innovative new products.

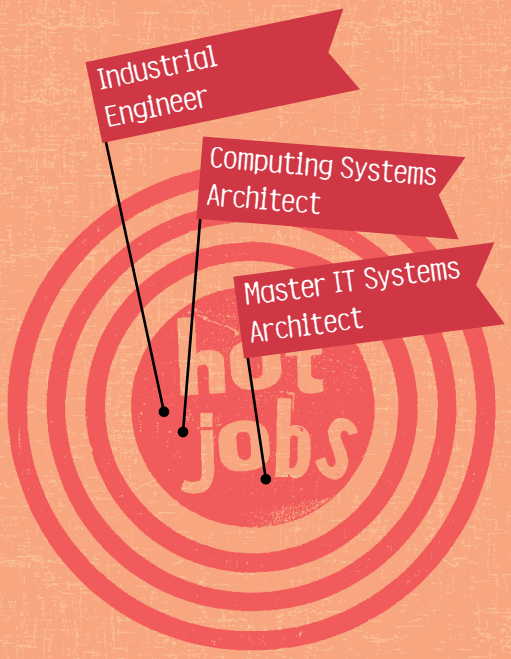
As a product designer, you could make the world a better place by…

- Designing a trash can that automatically sorts items based on whether they can be recycled or composted.
- Building a solar-powered water filter to allow even the poorest communities easy access to clean water.
- Creating a life-saving artificial heart made entirely of plastics and light metals.
- Designing a fully functioning bionic eye that lets people who have lost their sight see again.

Healing People Through Design

Name Lisette Miller
Job Senior Biomedical Engineer, Ximedica
She makes the world a better place by designing medical devices for treatment of hemorrhage and infection control.

Lisette Miller's company specializes in creating medical devices that help evaluate patients. In her job, she builds and tests prototypes, and uses a three-dimensional computer model to design the final product. Lisette loves that what she does contributes to saving lives, and she enjoys the hands-on aspect of her work. She offers this valuable advice: "If you're willing to work hard and you have the drive to succeed, definitely check out engineering—and don't let anyone convince you that you're not smart enough to do it!" Lisette's family strongly supported her pursuit of engineering. Her mom is from Puerto Rico, her father is from Colombia, and she grew up with two brothers in the Boston area.



Average Annual Salary

Starting: $75,000
Experienced: $95,000

SYSTEMS ARCHITECT

Google estimates there are more than a trillion—that's 1,000,000,000,000!—pages on the World Wide Web, and it would be impossible to find anything online without help. Whether it's creating systems to search the Web in less than a second or helping a family-owned company to work more efficiently, systems architects turn facts and figures into concrete processes.

As a systems architect, you could make the world a better place by…

- Designing a database that would allow every book ever written to be instantly searchable online.
- Improving the way people interact with ATMs so that neither customers nor teller machines make mistakes.
- Working with relief agencies to design the safest and most efficient processes to clean up after a natural disaster.

"We can't be globally competitive without girls and minorities in science careers. They bring a diversity of thought to the table, and that brings innovation."

— Dr. Alicia Abella

The Future Is Now

Name Alicia Abella

Job Executive Director, Innovative Services Research Department, AT&T Labs

She makes the world a better place by developing devices that will make life easier in surprising ways.

Alicia Abella and her team focus on projects that may have sounded impossible, even a few years ago: a headband that can read your brainwaves to determine your mood, or an earring that will gently vibrate when your cell phone rings in a purse or across the room. They are looking at ways to transfer information from one person to another through a handshake by conducting an audio signal through the bones. And they're even working on a service that will prevent people from forgetting things at home: By putting little RFID (radio frequency identification) tags, which are the size of stamps, on your belongings, your car can alert you if you're missing anything before you drive away. "We are investigating new technologies that will delight people with unexpected new abilities, and, dare I say, give them seemingly superhuman powers," Alicia says.

1 Imagine Your Cutting Edge Career

What makes a great career? Most people would agree on a good salary, a fun challenge, and being part of a creative team. What if you can make the world a better place, too? That's a dream job. Careers on the cutting edge of technology, science, and medicine are very desirable for all those reasons.

Use the following questions to imagine what kind of challenges would intrigue you. Then look at the chart to see which cutting-edge scientists might tackle those challenges.

	YES	NO	Software Engineer	Mathematician	Product Designer	Systems Architect
1 Could you see yourself developing a full-body video game controller for **virtual reality** chambers?	☐	☐	●		●	
2 Would you like to create a **microscopic headset** that could be implanted in your inner ear to let you hear and be heard perfectly?	☐	☐			●	
3 Could you see yourself creating a plan to completely **eliminate rush hour traffic** in a big city?	☐	☐		●		●
4 Could you imagine designing **robots** that could assist in surgeries like hip replacements or laser eye repair?	☐	☐			●	
5 Would you like to build **robot hawks** to keep flocks of geese and other birds away from airport runways?	☐	☐	●		●	●
6 Could you imagine yourself creating the world's first truly **driverless cars** and the roads they'd travel on?	☐	☐	●	●	●	●
7 Would you like to design a **lightweight wheelchair** that could be packed into a normal-size backpack?	☐	☐			●	
8 Would you like to create a program to cut our nation's obesity rates in half using a combination of diet, exercise, and **incision-free weight loss operations?**	☐	☐		●		●
9 Could you imagine designing an **online storage system** for users to save *all* their music, photos, and digital files without the possibility of ever losing them?	☐	☐	●	●		●
10 Would you like to figure out better ways to create job growth and **reduce unemployment** across the country?	☐	☐		●		●
Which scientist might you like to be? (Check one. You'll use this later.)			●	●	●	●

Reaching Your Future

1

We asked scientists from different fields what advice they would give to girls interested in science, technology, math, and engineering. Here's what they told us:

- **Find a mentor** to help you succeed in school and learn about math and science. Family members, school counselors, and Girl Scout volunteers are good mentors.
- **Think about what you want in the future** and then work toward that. Nothing comes easy. You can be cool and still get your homework done.
- **Stick with sciences and math**—these subjects are the passport to doing whichever science career you want.
- **Focus** not only on developing top-notch math and science skills but also excellent writing and speaking abilities.
- **Don't give up on education.** The more knowledge you have, the more powerful you are—no matter what you want to be.
- **Seek out opportunities** to meet female scientists and learn about their jobs. Ask if you can tour a business that employs scientists.
- **Listen to and observe** older people so that you won't have to learn everything the hard way.
- **Hold true to yourself.** If there is something you really want to pursue, you must do it. A career is something to be selfish about—it's not for anybody but yourself.
- **Explore and find something that is interesting to you.** You don't have to know exactly what you want to do. When you start going in one direction, you may find out about something completely new.
- **Ask for help.** If you still don't get it, continue to ask for help. Don't think you can ask only once or one person. Get a second opinion if you need it.
- **Always do your best.** Always try to act in such a way that if you died today, you can say that you have done your best.
- **Cultivate confidence** and good etiquette. Believe you are the best at whatever you are doing. But always be polite, and give back to others.
- **Tell your parents** or guardians why becoming a scientist is important to you.
- **Take advantage of free resources** on the Internet.
- **Remember that you can follow your dream** and still surround yourself with people who care for you.
- **Look for fun ways to learn** more about math and science. For instance, seek out camps or after-school clubs related to science, robotics, and engineering.
- **Mentor others.** Reach out to someone younger than yourself and be her role model!

Imagine Yourself in a Lab

2

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!

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

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.

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.

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%

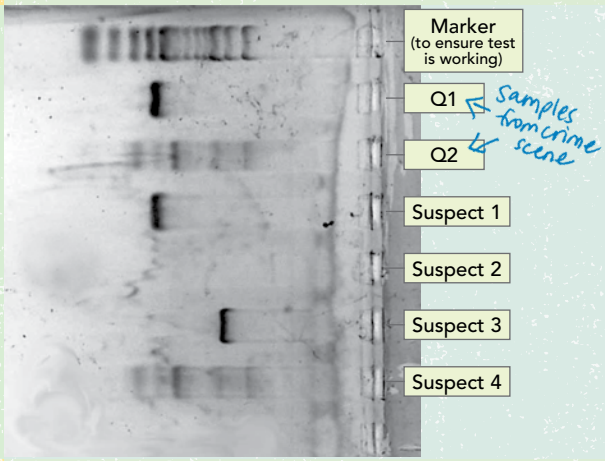
IMAGINE MORE

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.

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.

Photo courtesy Michigan State University, Forensic Science Department

FOOD SCIENCE CHALLENGE

2

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

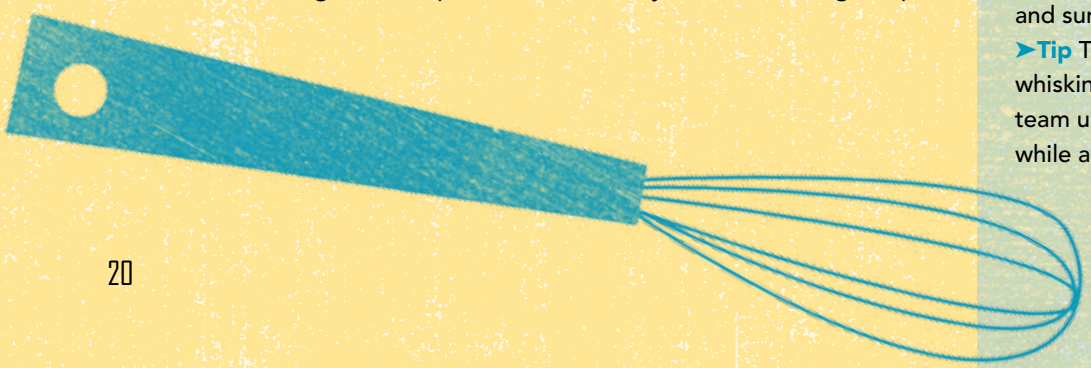
- Review **The Science of Emulsions** on the next page.
- Follow the recipe. Record in your notebook which emulsifier you chose, how long you whisked, and a description of the resulting emulsion. *Are there visible droplets of oil or vinegar? Do you see layers?* **➤Tip** Tilt the cup to check consistency.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

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.

- Don't forget to keep records. You may have a winning recipe!



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 emulsifer (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.

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
1 Water-in-oil emulsion
2 Can't tell
4 Oil-in-water emulsion

Flavor, aroma
1 Okay
2 Good
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							

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!

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?*

IMAGINE MORE

TEST THE GLUTEN IN FLOUR

Gluten is a protein found in wheat, rye, and barley. Extract a ball of gluten from different types of flour to see what this stretchy grain protein looks like. Ask your volunteer to share the details about how you can do this.

Look below for some info on possible ingredients.

2

Added in the Lab

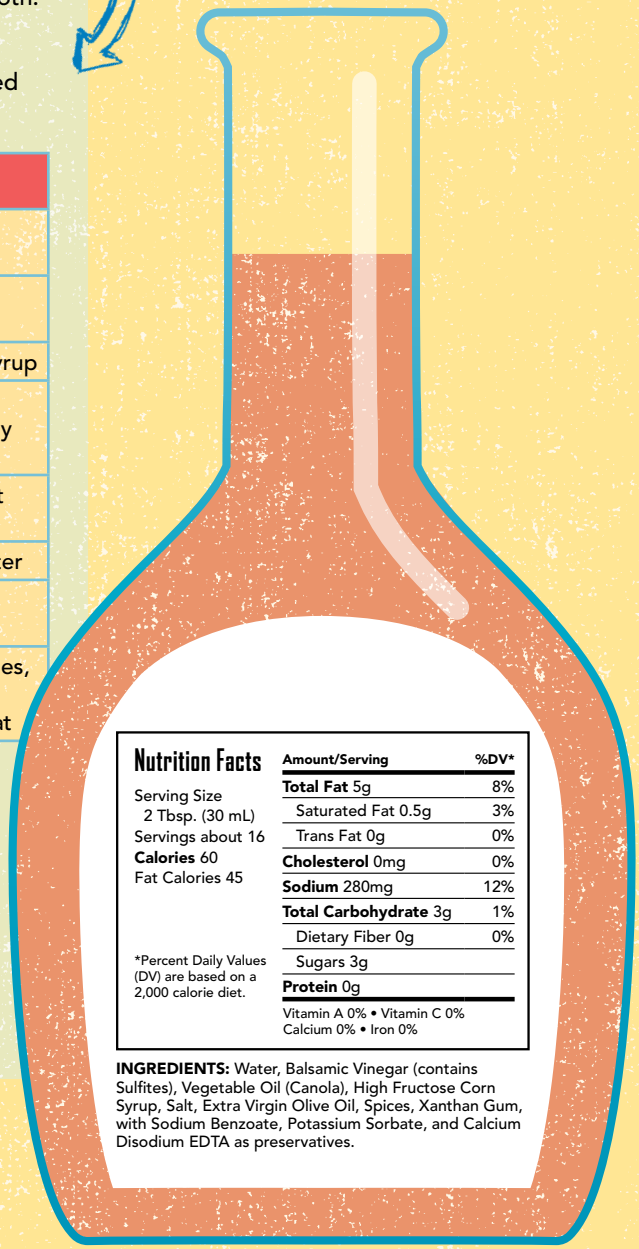
Common commercial **emulsifiers** are soy lecithin, mono- and digylceride, polysorbates, and gums—often added in the lab to keep salad dressing, peanut butter, and ice cream looking smooth.

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
Mono- and digylceride	emulsifies	fatty acids	muffins, bagels, pasta
Lecithin	emulsifies	soybeans	cheese, baked goods, chocolate
Carrageen	thickens	seaweed	ice cream, jelly, syrup
Agar	thickens	algae	marshmallows, gummy bears, jelly beans
Sodium benzoate	preserves	salt	pickles, jams, fruit juice
BHA	preserves	antioxidants	cereal, meat, butter
Caramel color	adds brown color	caramelized sugar	cookies, potato chips, soda
Carmine	adds red color	cochineal insects	maraschino cherries, strawberry milk, imitation crab meat

What's in This Vinaigrette?

- Water is the main ingredient in this vinaigrette (based on a real product).
- Many commercial vinaigrettes include high fructose corn syrup as a sweetener.
- Can you spot the emulsifier?



Nutrition Facts

Serving Size 2 Tbsp. (30 mL)
Servings about 16
Calories 60
Fat Calories 45

*Percent Daily Values (DV) are based on a 2,000 calorie diet.

Amount/Serving	%DV*
Total Fat 5g	8%
Saturated Fat 0.5g	3%
Trans Fat 0g	0%
Cholesterol 0mg	0%
Sodium 280mg	12%
Total Carbohydrate 3g	1%
Dietary Fiber 0g	0%
Sugars 3g	
Protein 0g	

Vitamin A 0% • Vitamin C 0%
Calcium 0% • Iron 0%

INGREDIENTS: Water, Balsamic Vinegar (contains Sulfites), Vegetable Oil (Canola), High Fructose Corn Syrup, Salt, Extra Virgin Olive Oil, Spices, Xanthan Gum, with Sodium Benzoate, Potassium Sorbate, and Calcium Disodium EDTA as preservatives.

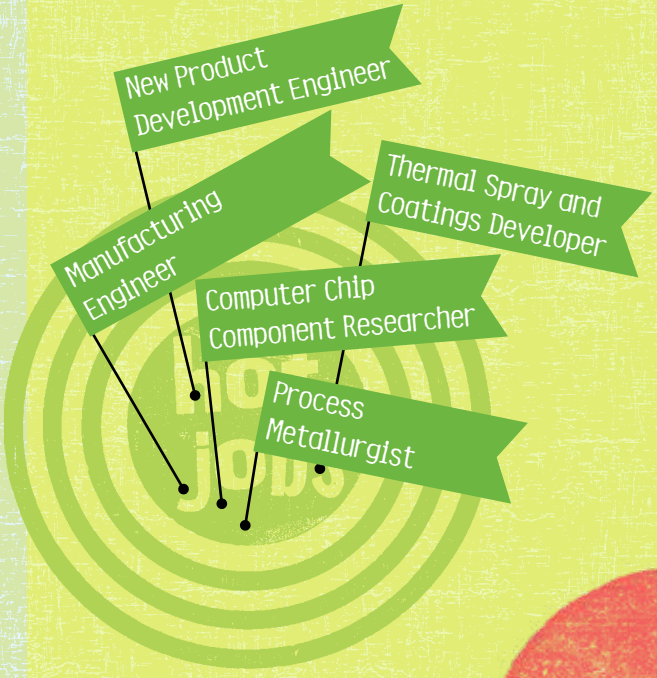
Imagine Yourself in a Lab

MATERIALS SCIENTIST

Materials scientists help make everything from the rubber on the bottom of running shoes to the graphite fibers used to build space satellites. Like inventive chefs, these scientists experiment with different molecules and unusual materials in their hunt for new products. Armed with a strong knowledge of chemistry, materials scientists must be curious and willing to fail over and over again before they succeed.

As a materials scientist, you could make the world a better place by…

- Working for a major car company to create a lightweight metal alloy that never rusts.
- Creating an affordable, shatterproof ceramic that could be used in plates and cups guaranteed to last for decades.
- Inventing a glass for TV and computer screens that's smudge-proof, lightweight, and stronger than steel.
- Creating ink for home printers made entirely from organic sources like beets and algae.



Average Annual Salary

Starting $60,000
Experienced $85,000

2

Fashion-Forward Science

Name Suzanne Lee

Job Founder, BioCouture Ltd.

She makes the world a better place by uniting biology and design to create sustainable future fashion.

"I was bottom of the class in science," Suzanne Lee says. "Hated it. Went to art school to do something I loved." As a fashion designer, however, she became unhappy about the waste and toxicity the industry generated. So today she collaborates with scientists to work on sustainable alternatives, including fibers made by microbes. These bacteria spin microfibrils of pure cellulose as they ferment, producing a dense layer, which she harvests, dries, and turns into clothing. "The material is nearest in feel to a vegetable leather," Suzanne reports. "And, like your vegetable peelings, it can be safely composted when you no longer want it." Her company is pioneering the application of all kinds of new biomaterials, not only for clothing but also for shoes, bags, and jewelry.

2

BIOLOGIST

Biologists study life—from people and penguins to bats and bacteria. If nature is a giant puzzle, biologists piece sections of the puzzle together to discover how living things fit together. Some biologists never leave the lab, while others spend most of their time outside studying animals in the wild.

As a biologist, you might make the world a better place by…

- Protecting the honeybee populations that pollinate a third of the U.S. food supply by breeding disease-resistant species.
- Studying how butterflies respond to climate change and how that affects where they can live.
- Analyzing rare orchids in the Amazon rain forest to discover new medicines.

Average Annual Salary

Starting $45,000
Experienced $65,000

Branching Out

Name MariaElena Zavala

Job Plant Biologist and Professor of Biology, California State University, Northridge

She makes the world a better place by researching how plants sense their environment and mentoring minority students.

MariaElena Zavala grew up in Laverne, California, in a close-knit Mexican-American family and earned her degree in botany. MariaElena was also the first person in her family to earn an undergraduate degree—and, eventually, a PhD. Her path wasn't easy as a minority, nor as a woman. "But I just didn't care," MariaElena says. "I could tell that some people didn't expect me to do well. But it was just not seen as weird in my family that I wanted to do math or science."

Today, she studies chemical and environmental signals that cells in plant roots use to determine where and when to divide to make branch roots. "Once I took my father's roses apart," she recalls. "I was trying to see how the parts fit together, and I ended up decimating his rosebushes. Now I get paid to do the same thing!"

Photo by Paul Talley, courtesy CSUN

MariaElena Zavala (center).

FORENSIC SCIENTIST

Forensic scientists use science skills to solve mysteries related to the law. The best-known forensic scientists work for law enforcement, analyzing crime scenes for evidence like fingerprints and tire skids. But there are many other types of forensic scientists: Some investigate computer systems for lost and stolen data, others specialize in identifying counterfeit money and paintings, and others recover and identify bones.

As a forensic scientist, you might make the world a better place by…

- Partnering with the curator of an art museum to ensure that its purchases are really by famous artists and not forgeries.
- Interpreting speech and language used in court testimonies.
- Identifying a suspect by analyzing DNA from a crime scene.
- Examining failed structures like collapsed bridges to figure out what went wrong.

Average Annual Salary

Crime scene investigator $50,000 to $65,000

Crime laboratory analyst $60,000

Forensics engineers $70,000

Fabulous Forensics

Name Antoinette T. Thwaites

Job Forensic Chemist; CEO/Founder, Association of Women in Forensic Science, Inc.

She makes the world a better place by using chemistry to analyze drug evidence.

Antoinette Thwaites went to public school in Philadelphia, and her strong interest in pharmacology—a field that studies how drugs affect the brain and body—drove her to earn a Bachelor of Science degree in chemistry. When she graduated, she landed a forensic chemist position with the City of Philadelphia.

In her job today, Antoinette analyzes drug evidence and identifies drugs—prescription and illegal—from criminal investigations and testifies as an expert at trials. She shares her expertise by speaking to groups about forensic science and drug awareness. Antoinette also started the Association of Women in Forensic Science to mentor girls and women who seek forensic science careers.

Courtesy Association of Women in Forensic Science, Inc. (AWIFS)

2

FOOD SCIENTIST

It's commonly said that food scientists work on "everything from field to fork." Some spend their whole career studying genetically modified crops. Some create packaging to help food last longer in supermarkets. And some spend their time figuring out how to make the perfect French fry. In short, food scientists can turn any lab into a kitchen, and any kitchen into a lab.

As a food scientist, you might make the world a better place by…

- Helping end food shortages by developing rice seeds that require less time and water to grow.
- Working for a major ice cream maker, finding new ways to flash-freeze fruits to create easy and delicious desserts.
- Helping genetically engineer a new strain of corn that's easier to convert into eco-friendly ethanol fuel.
- Finding more efficient ways to raise and serve tasty insects and worms (called entomophagy), which are high-protein food that has a low impact on the environment.

Average Annual Salary

Starting $50,000
Experienced $65,000

Ice Cream of the Crop

Name Kirsten Schimoler

Job Principal Food Scientist, Ben & Jerry's Ice Cream

She makes the world a better place by making dessert even more delicious.

Kirsten Schimoler combines culinary arts with science and technology to create new flavors of Ben & Jerry's ice cream. Two of her creations? Chocolate Nougat Crunch ice cream and Blueberry Vanilla Graham Greek Frozen Yogurt. "Growing up, I loved to cook," Kirsten says. "My brother and I would go into the kitchen and create things." A day at work for Kirsten includes: "eating, ideation, developing, redeveloping, tasting, laughing, production runs, and some paperwork." She earned a degree in food science from Cornell University and has also created home bistro meals for the P.F. Chang's restaurant chain.

Photo by Alex Rice-Swiss

Imagine Your Lab Career

Some laboratories are spotless rooms full of scientists peering into microscopes. Others contain high-powered computers, famous artworks, or fridges full of food. And some labs—from a dinosaur dig to busy city street corner—may not even be inside.

Use the following questions to imagine what kind of laboratory challenges intrigue you. Then look at the chart to see which scientists might tackle those challenges.

	YES	NO
1 Could you imagine creating airplane fuel using only biofuels like soybean oil and recycled restaurant grease?	☐	☐
2 Could you imagine investigating the effects that pets have on people's overall happiness?	☐	☐
3 Would you like to create a new type of glass to keep priceless paintings by artists like Picasso in perfect condition for a thousand years?	☐	☐
4 Could you imagine studying diabetic monkeys to help create a new pill to that could cure diabetes in humans?	☐	☐
5 Would you like to work for NASA, creating freeze-dried astronaut food that's portable, lightweight, and tasty?	☐	☐
6 Could you imagine studying tiny particles in meteorites for evidence of life on other planets?	☐	☐
7 Would you like to work for a major cosmetics company, creating eco-friendly pigments for nail polishes?	☐	☐
8 Would you like to work for the FBI, interviewing criminals and analyzing crime patterns to help make urban areas safer?	☐	☐
9 Could you imagine being part of the molecular gastronomy movement, cooking up edible inks or desserts meant to be inhaled instead of chewed?	☐	☐
10 Would you enjoy creating new ingredients for perfumes that last longer and make people happier?	☐	☐

Which scientist might you like to be? (Check one. You'll use this later.)

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

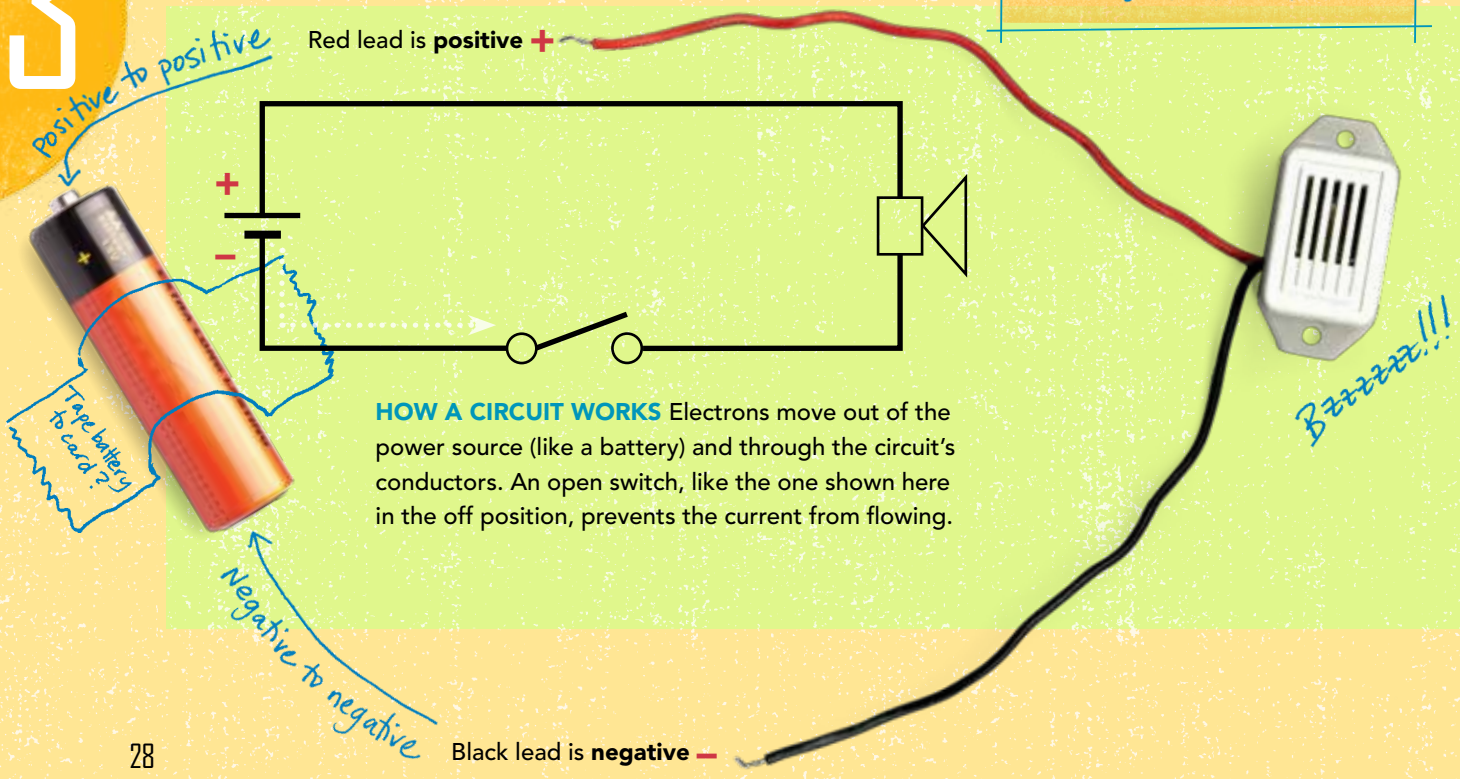
Build a simple circuit with the battery as a power source and the buzzer as your load (or device that uses the power).

- 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.

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

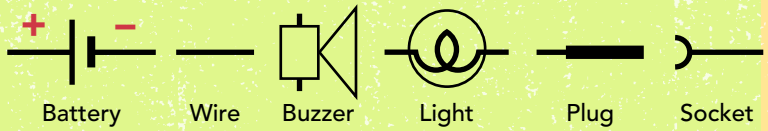
If a switch isn't working, ask yourself:

- ☐ *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?*

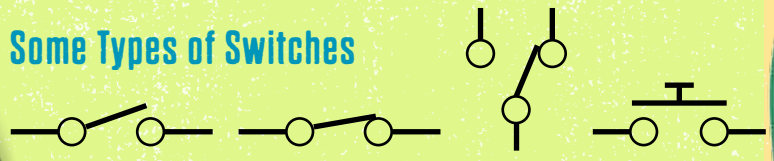
IMAGINE MORE

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.

Some Circuit Symbols



Some Types of Switches



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!

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

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.

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 a 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 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

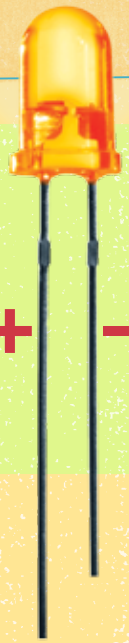
On a piece of paper, sketch the electrical connections (conductive thread) and placement of your components (LED light in front, battery pack on back).

- 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

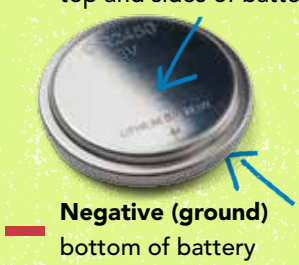
- Color the longer (anode) leg of your LED red with a permanent marker to mark its polarity. By hand or using needle-nose pliers, curl the LED legs (wires) so that they can be sewn to your fabric.

Identify Polarity



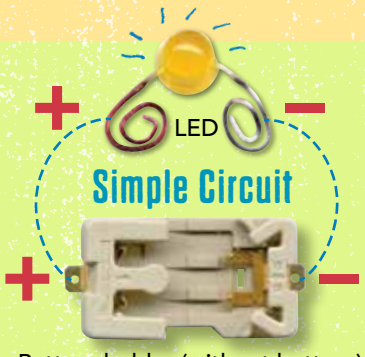
Positive (anode) leg of LED is longer

Negative (cathode) leg is shorter



Positive (power) top and sides of battery

Negative (ground) bottom of battery



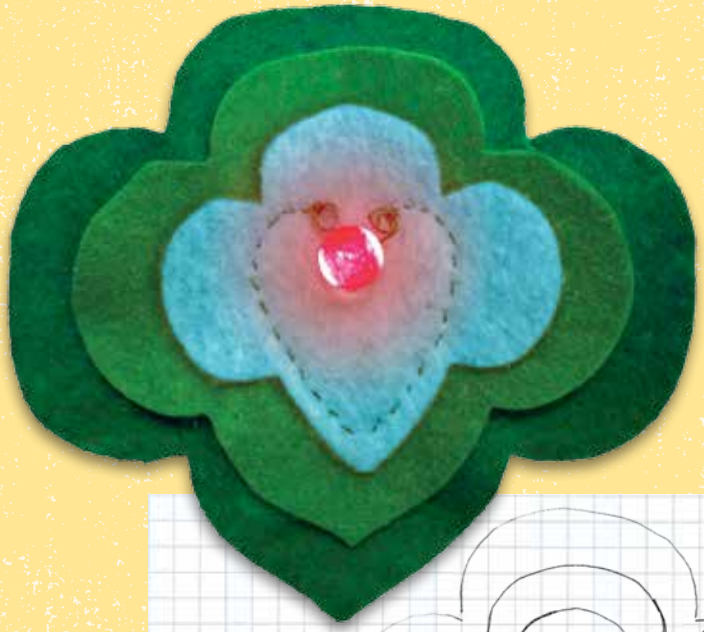
Battery holder (without battery)

STEP 4: BEGIN SEWING!

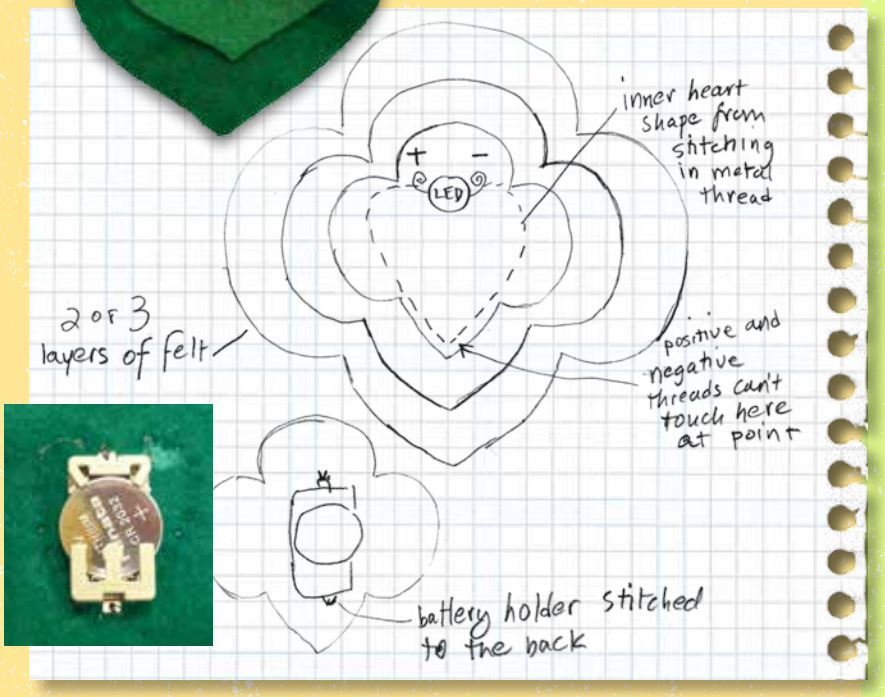
- Follow your chalk pattern to sew the connections between components. Conductive thread frays easily, so you might use needle threaders to help thread your needle. Make sure to sew each component securely to the fabric before sewing between components. After sewing the connections, tie knots on the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

Imagine Yourself as an Engineer

ENVIRONMENTAL ENGINEER

Environmental engineers are on a mission to save the planet. They use engineering skills to protect people, wildlife, and landscapes, ranging from city parks to the ocean floor. These engineers work hard to create new uses for recycled materials, figure out ways to reduce pollution, and clean up dangerous waste.

As an environmental engineer, you could make the world a better place by…

- Consulting with auto manufacturers on ways to reduce carbon emissions from their factories.
- Working for the U.S. government's Environmental Protection Agency to track possible radiation leakage from nuclear power plants.
- Transforming unwanted fabrics into fashionable purses and backpacks.

Average Annual Salary

Starting $48,000
Experienced $75,000

3

Wind for a Healthier Planet

Name Trudy Forsyth

Job Managing Director, Wind Advisors Team

She makes the world a better place by increasing the nation's output of clean, green energy.

Trudy Forsyth, a former Girl Scout, travels the country to explain wind energy and to promote small wind turbines. She helps farmers, ranchers, and homeowners install the turbines on their property. Trudy loves the opportunities she's had as a woman with an advanced science degree—in her case, mechanical engineering. Women in engineering, she says, are a lot like wind energy: just getting going and poised to make an important contribution to the planet. She explains, "The more we can take the burden off the polluting energy technologies and those that require water, the healthier the planet will be."

CIVIL ENGINEER

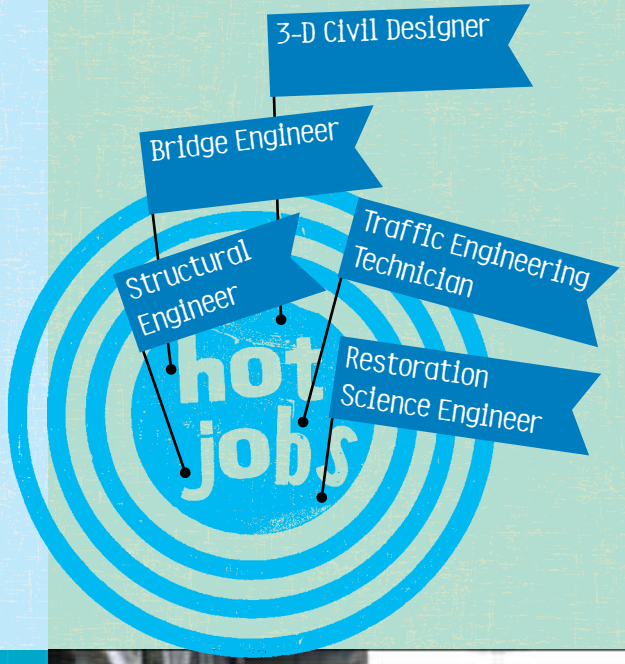
Civil engineers design and build everything, from the roads we drive on to the buildings we learn and shop in. They've helped create everything from the pyramids in ancient Egypt to modern marvels like the New York City subway, the Golden Gate Bridge, the Hoover Dam, the U.S. Interstate Highway System, and the Chunnel connecting England and mainland Europe—underwater.

As a civil engineer, you could make the world a better place by…

- Reviewing blueprints for a new giant skyscraper in Chicago to make sure it can withstand strong winds.
- Creating plans to convert an unused city square into a new public concert venue.
- Testing the safety of Pittsburgh's many bridges.

Average Annual Salary

Starting $55,000
Experienced $78,000



Sounds of Silence

Name Erin Slayton

Job Civil Engineer

She makes the world a better place by decreasing traffic noise.

Erin Slayton manages a $14 million program to build noise-reducing walls alongside Interstate 5 in Seattle. Her work means that nearby residents sleep through the night. "Building [these walls] is much more complicated than it appears," Erin explains. She must measure noise to determine where the problems are; figure out how tall, long, and wide the walls should be; and make sure the soil can support them.

Erin's job also includes a human component: She works to balance the engineering issues with surrounding ecosystems and community politics. And she loves her job. In high school, she saw a video of the Tacoma Narrows Bridge collapsing into Puget Sound, and knew she wanted to be an engineer. "Engineering has given me so much," Erin says, "a lifetime of solving problems and helping people."

Photo courtesy National Renewable Energy Laboratory

MECHANICAL ENGINEER

Mechanical engineers design the things that make your life easier and more fun, from MP3 players and bikes, to subways and cars, to the duct and vent systems that heat and cool public buildings. If something moves or turns on and off, a mechanical engineer was likely involved!

As a mechanical engineer, you could make the world a better place by…

- Building a more aerodynamic windshield for an electric car.
- Designing a new cell phone powered entirely by the enzymes (substances that help chemical reactions occur) in cola.
- Designing the machinery needed to construct laptop computers.

Average Annual Salary

Starting $60,000
Experienced $85,000

3

Design for Global Change

Name Heather Fleming

Job Product Designer and CEO, Catapult Design

She makes the world a better place by creating new products and technologies for disadvantaged people around the world.

When Heather Fleming was a young girl, she didn't even know what the word *engineer* meant. She thought she would go to art school. "My freshman year, it seemed that everyone but me had taken Advanced Placement classes in high school," Heather says. "One way that I overcame this was through a program for minority kids who didn't have access to AP and honors courses." Today, she runs a design company that works with disadvantaged or marginalized communities. One of its projects is to help design a better way for women and girls in isolated communities in India to haul water from the source to their homes, using an action similar to pushing a grocery cart.

"If you want to be an engineer but can only draw a picture, that's okay. Don't be afraid to ask for help. I ask for help all the time."

—Heather Fleming

Drew Kelly

CHEMICAL ENGINEER

Like using toothpicks to build a model of the Eiffel Tower, chemical engineers painstakingly piece together tiny molecules into new and exciting forms. Using their knowledge of chemistry, physics, and biology, modern-day chemical engineers improve our lives by developing everything from batteries that last longer to ways to mass-produce medicines that save countless lives.

As a chemical engineer, you could make the world a better place by…

- Creating lithium ion batteries for artificial hearts that run for a decade or more without needing to be recharged.
- Working on a team of scientists dedicated to building the first hydrogen-powered airplane, fueled only by the hydrogen in the air.
- Constructing the synthetic fibers that make clothes more comfortable and water resistant.

Average Annual Salary

Starting $66,000
Experienced $90,000

Career Chemistry

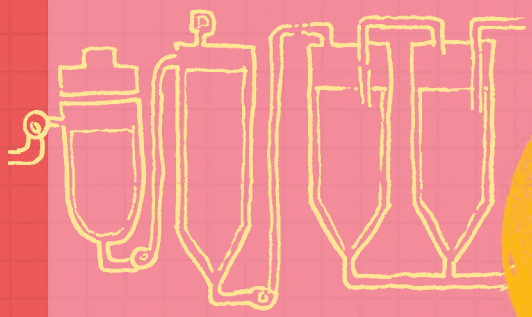
Name Deya Riojas-Glover

Job Process Engineer, Sherwin Alumina Company

She makes the world a better place by extracting alumina from bauxite ore for aluminum foil, medicines, and other products.

At 26, Deya Riojas-Glover was a single parent of two. "I didn't want to spend the rest of my life working minimum-wage jobs," she says. "A friend was studying to become a chemical engineer and encouraged me to do the same." Deya loved chemistry and math in high school, so she found financial aid, scholarships, and grants to get through college. "The day I received my degree, my children were extremely proud of me," she says.

Today, she uses her chemical engineering degree at a great job that keeps her physically and mentally active: Deya makes sure the equipment that extracts the ore works smoothly, and she monitors the process for proper chemistry. She's also involved in projects that enhance the Bayer process (which produces alumina from bauxite by digesting it in hot sodium hydroxide solution) and troubleshoots problems along the way.



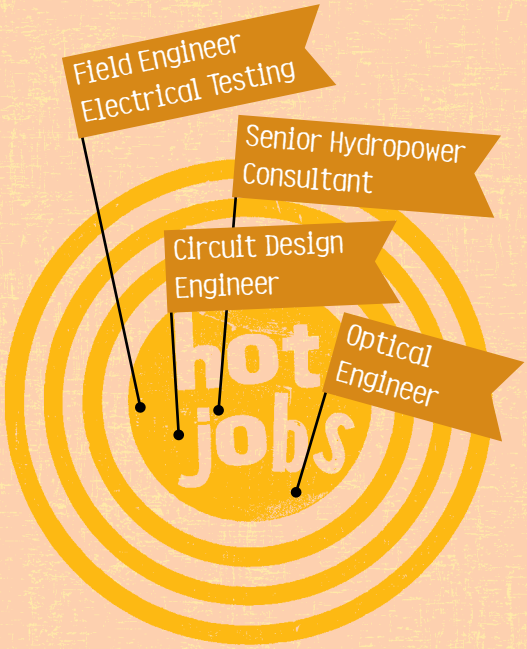
3

ELECTRICAL ENGINEER

Everything that uses electricity—from cars to cranes to computers—was created with the help of an electrical engineer. Some electrical engineers make products like control systems for airplanes, 3-D televisions, laser scanners, and GPS satellites. Others spend time in labs dreaming up improvements for computer chips and robot technology.

As an electrical engineer, you could make the world a better place by…

- Working in an ocean-side lab, figuring out new and improved ways to turn the power of waves into clean energy.
- Creating digital inks for e-reader machines that are as easy to read in sunshine as they are in the dark.
- Designing a satellite that could warn people about dangerous weather conditions.



Average Annual Salary

Starting $61,000
Experienced $87,000

3

The Sky's the Limit

Name Debra Coleman

Job Electrical Engineer, Boeing

She makes the world a better place by making sure the electrical wiring in airplane galleys and lavatories are correct, which keeps passengers and crew safe.

Growing up in Sacramento, California, Debra Coleman's mom made sure she took the right classes and was involved in after school activities. In high school, she joined MESA (Mathematics Engineering Science Achievement) and had the chance to compete and travel. Still, she shied away from engineering because she thought it might be too "nerdy." But her potential and grades were strong enough that her college counselor encouraged her to give it a try. "She said I could always switch majors if I didn't like it," Debra recalls. "Luckily, I liked engineering so much that I went on to graduate school." She ended up earning two masters degrees, one in computer information systems and another in electrical engineering. Today, in her job for Boeing, Debra oversees things like making sure the devices in airplanes' galleys, which include the microwave ovens and coffeemakers, are wired properly for safe operation.

Imagine Your Engineering Career

Engineers are creative problem solvers who help people lead better lives. Using math and science skills, they improve everything from the smallest molecules to the tallest skyscrapers. Engineers work to make things and processes more efficient, more powerful, less expensive—and more amazing.

Use the following questions to imagine what kind of engineering challenges intrigue you. Then look at the chart to see which scientists might tackle those challenges.

	YES	NO
1 Would you like to design an air-conditioner powered only by solar energy?	☐	☐
2 Could you imagine working with world-renowned architect Zaha Hadid to build a modern museum made almost entirely of recycled materials?	☐	☐
3 Would you like to use high-tech robotics to find new ways to design walls and ceilings so they're beautiful, strong, and use half the concrete of traditional structures?	☐	☐
4 Could you imagine designing a machine to drill the deepest highway mountain tunnel in the world?	☐	☐
5 Could you imagine designing a robotic submarine that could stay underwater for weeks at a time?	☐	☐
6 Would you like to design San Francisco skyscrapers to withstand huge earthquakes and keep occupants safe?	☐	☐
7 Would you like to invent tiny medical devices that repair human organs from inside the body?	☐	☐
8 Would you like to design efficient windmills that produce as much energy as coal power plants but less pollution?	☐	☐
9 Would you like to manage the work site for an entirely new, eco-friendly subway line in New York City?	☐	☐
10 Could you imagine developing quick and easy ways to turn saltwater into drinking water to help end water shortages around the world?	☐	☐

Environmental Engineer	Civil Engineer	Mechanical Engineer	Chemical Engineer	Electrical Engineer
●	●	●		●
●	●			
	●	●		
	●	●		●
				●
●	●			
		●	●	●
●		●		●
●	●			●
●			●	
●	●	●	●	●

Which scientist might you like to be? (Check one. You'll use this later.)

3

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.

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

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.

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	

4

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.

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.

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

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**.

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.

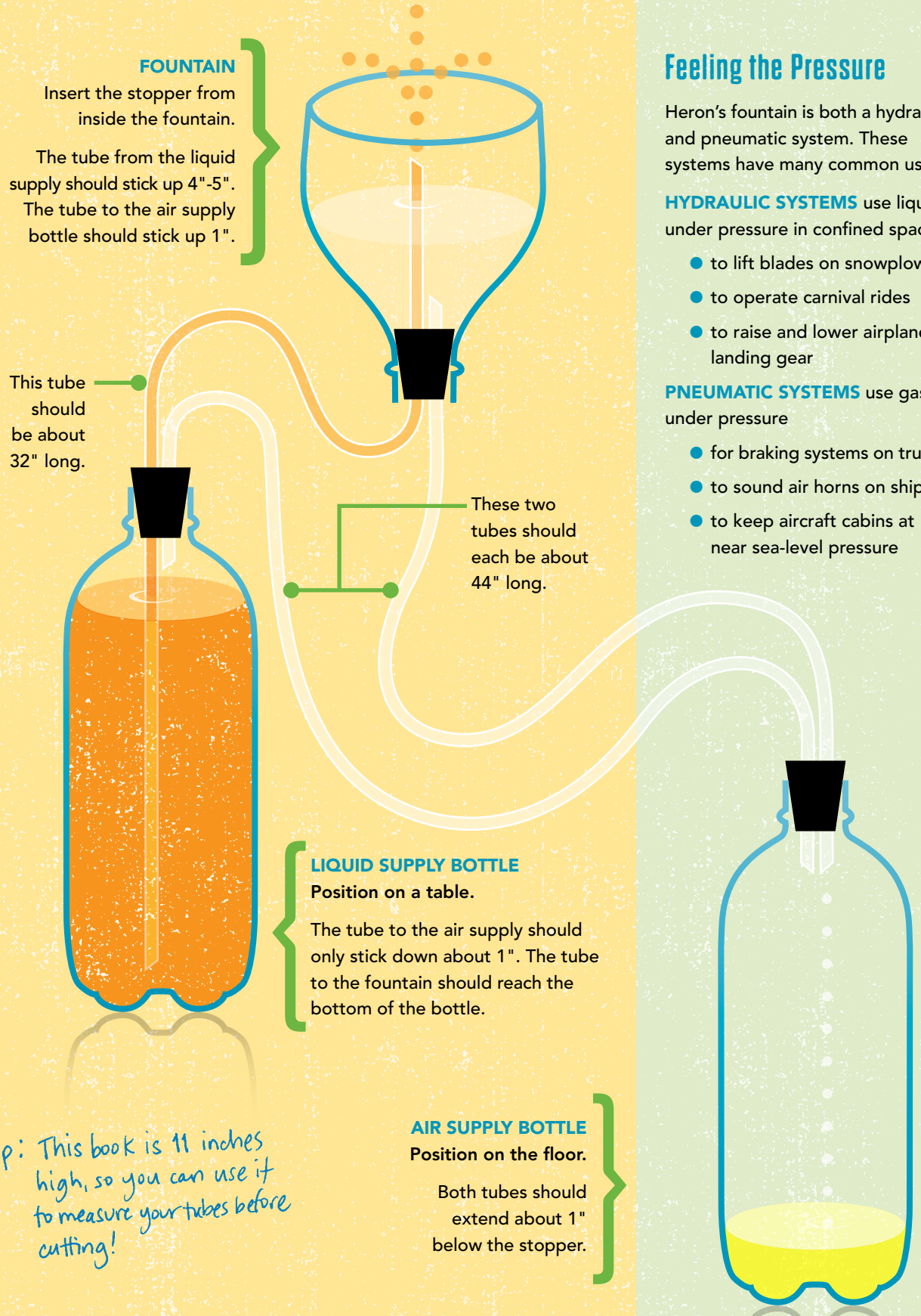
STEP 2: BUILD YOUR FOUNTAIN

- 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.

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.

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.



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

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

4

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

People have been extracting energy from wind and flowing water for more than a thousand years with simple machines like windmills and waterwheels. Today, we use some of the same mechanical principles to build ever-more-efficient green machines.

TURBINES use currents of fluid (even air is considered a fluid!) to push blades, causing them to rotate in a shaft. The shaft can be connected via gears to a machine that turns millstones to grind flour or pumps water for irrigation. Windmills and waterwheels are two kinds of turbines.

HYDROELECTRIC PLANTS use giant turbines to capture the tremendous energy of rivers falling over man-made dams or natural waterfalls. As water falls from a height, it picks up speed—converting potential energy to kinetic energy, just as Heron's fountain does. Spinning turbines turn this into energy to power our electric grid.

MODERN WINDMILLS use huge blades—propellers—shaped to capture as much energy as possible from air currents. The blades are high off the ground because winds are faster at higher elevations. In wind farms, windmills are spaced far apart so they don't steal wind from one another.

IMAGINE MORE

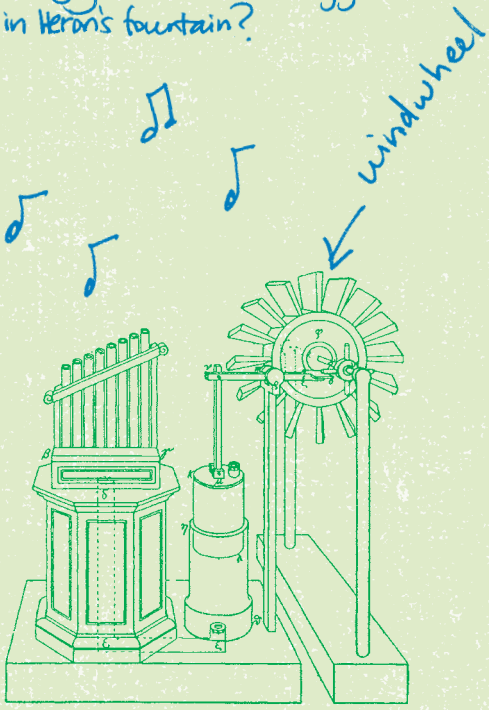
VISCOUS DRAG Using fluid mechanics, environmental engineers study how fluids react to forces, which helps to understand volcano behavior, weather patterns, oceanography, and much more. Have some fun finding out about the different properties in liquids. Ask your volunteer for details about how you can do this activity.

Talking Energy

POTENTIAL ENERGY Energy an object has because of its position or how its parts are arranged. Types of potential energy include chemical, gravitational, and electric.

KINETIC ENERGY Energy possessed by an object in motion. The faster an object moves, the more kinetic energy it has. Falling water, for example, gains kinetic energy as it falls.

How are gravitational potential energy and kinetic energy used in Heron's fountain?



Heron is also famous for his aeolipile, a kind of steam-powered engine, and this windwheel, which he used to power an organ!

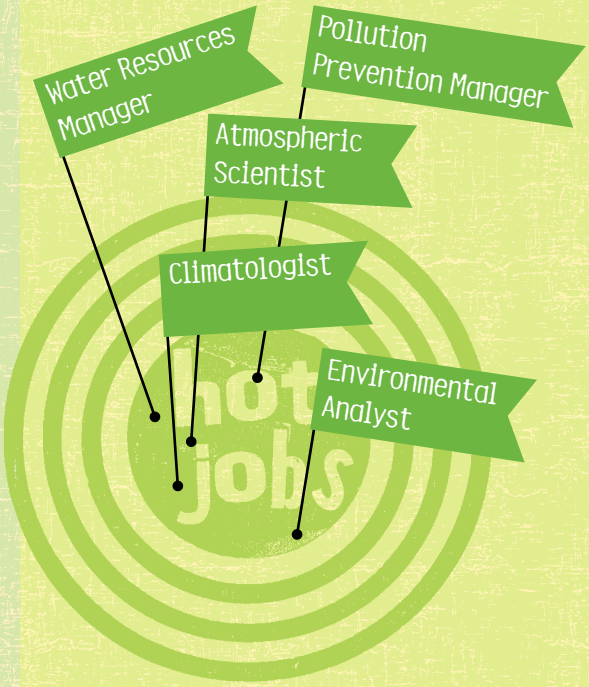
Imagine Saving the Planet

ENVIRONMENTAL SCIENTIST

Environmental scientists are concerned with the ever-growing list of problems facing our environment today. Some find and clean up existing pollution, and some design and implement new ways to avoid pollution in the future. Others study weather systems to better understand how human activity affects our climate. Together, these scientists are leading us to a healthier, greener tomorrow.

As an environmental scientist, you could make the world a better place by…

- Studying the negative effects on nearby marine wildlife of a proposed expansion of New York City's LaGuardia Airport.
- Analyzing data from satellites and radar to predict and track hurricanes in the Atlantic Ocean.
- Acting as an expert witness for a firm specializing in environmental law in cases against top polluting companies.



Average Annual Salary

Starting $50,000
Experienced $70,000

Positive Energy

Name Tanya Martinez

Job Environmental Scientist; Community Developer

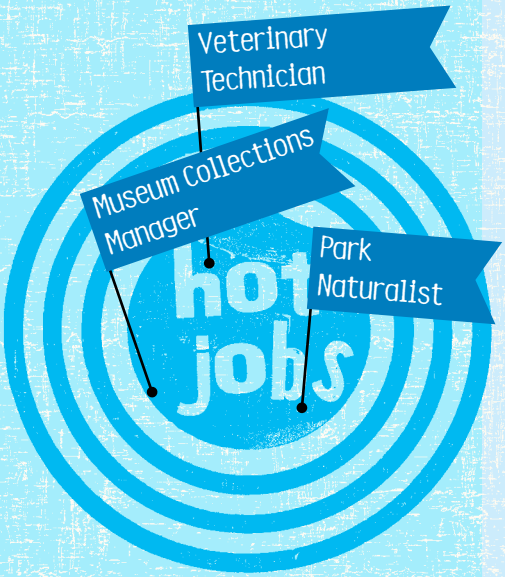
She makes the world a better place by helping American communities expand their renewable energy sources.

Tanya Martinez, part Mi'kmaq (indigenous people from Canada) and part Puerto Rican, had a dream in high school to get a Bachelor of Science degree. "I had a keen interest in my culture, math, science, history, and politics and wanted a career that I was passionate about," she says. "I [earned] a Bachelor of Science degree in electrical engineering and a Master of Science degree in energy engineering. I had no idea I would end up in the renewable-energy industry and work with American Indian Tribal Nations."

Today, Tanya develops solar power plants throughout the desert southwest, and was involved in installing a large solar power plant in Borrego, California. She has worked on other renewable-energy projects, including wind and biomass with many Native American communities, including her own, the Eel River Bar Mi'kmaq First Nation, in New Brunswick, Canada. She says, "I am inspired to work on energy projects that are good for the environment and good for the future generations."

Average Annual Salary

Starting $50,000
Experienced $66,000



ZOOLOGIST

Don't let the word *zoo* in *zoologist* fool you. While some of these scientists work in zoos, even more spend their time with animals elsewhere, from labs and farms to the wildest places on Earth. The goal of zoologists is to learn all they can about everything from the cell structure of starfish to the migration patterns of pronghorn antelope. In short, zoologists are a voice for animals, saving the planet by protecting their habitats.

As a zoologist, you could make the world a better place by…

- Studying grizzly bears in Montana's Glacier National Park to better understand if the melting of the park's glaciers is endangering their health.
- Opening a veterinary office to care for dogs, cats, and other pets in your community.
- Leading the team bringing the endangered California condor back from the brink of extinction by reintroducing birds into the wild and protecting their habitat.

Mark Thiessen/National Geographic Stock

Wild Work

Name Mireya Mayor

Job Explorer; Wildlife Expert; TV Wildlife Correspondent

She makes the world a better place by educating people about wildlife so they will protect it.

Mireya Mayor grew up as a city girl in Miami—the only daughter of Cuban immigrants. "My dream in high school was to bring pertinent news to worldwide audiences. At the time, I didn't know that news would consist of wildlife and habitat issues around the world. But my passions for conservation and journalism merged, and I became a wildlife correspondent for *National Geographic*."

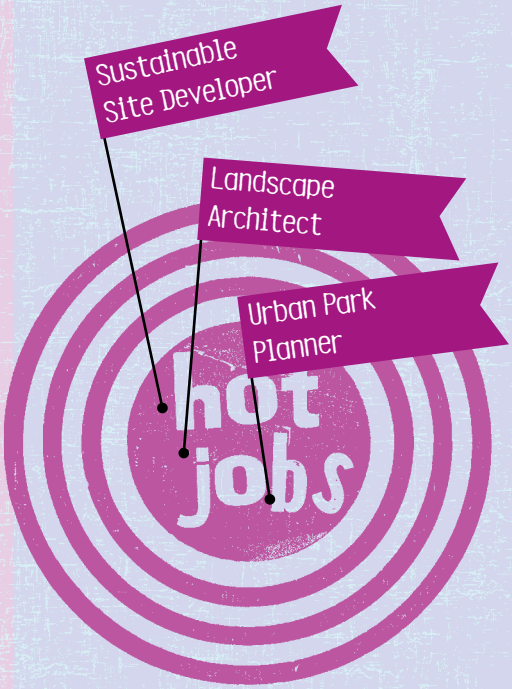
A former cheerleader for the Miami Dolphins, she didn't start studying science until college. In fact, Mireya had never been camping before her first jungle expedition, which she spent trying to avoid snakes and tarantulas! In 2000, Mireya codiscovered the world's smallest primate, the mouse lemur. She eventually convinced Madagascar's leaders to declare the species' habitat a national park. "Television has the power to help people know about these animals and habitats that are disappearing," Mireya says. "If we don't act now, it will be too late."

ARCHITECT

Few professionals have embraced the idea of going green faster than architects. Single-family homes, towering skyscrapers, bridges, and other structures are now being designed with green materials and energy-saving layouts. Why? It's simple. Not only are customers happier with eco-friendly projects, the structures themselves often cost less to maintain. They require less electricity, heating, cooling, and other expensive energy sources.

As an architect, you could make the world a better place by…

- Designing a library powered by solar panels on the roof.
- Making factories more eco-friendly by installing green roofs, complete with grass and other plants that reduce each factory's energy consumption.
- Building attractive and eco-friendly walls to help stop the erosion on key wetlands along the coast of Louisiana.



Average Annual Salary

Starting $45,000
Experienced $60,000

Creating Farms for the City

Name Robin Elmslie Osler

Job Principal, EOA/Elmslie Osler Architect

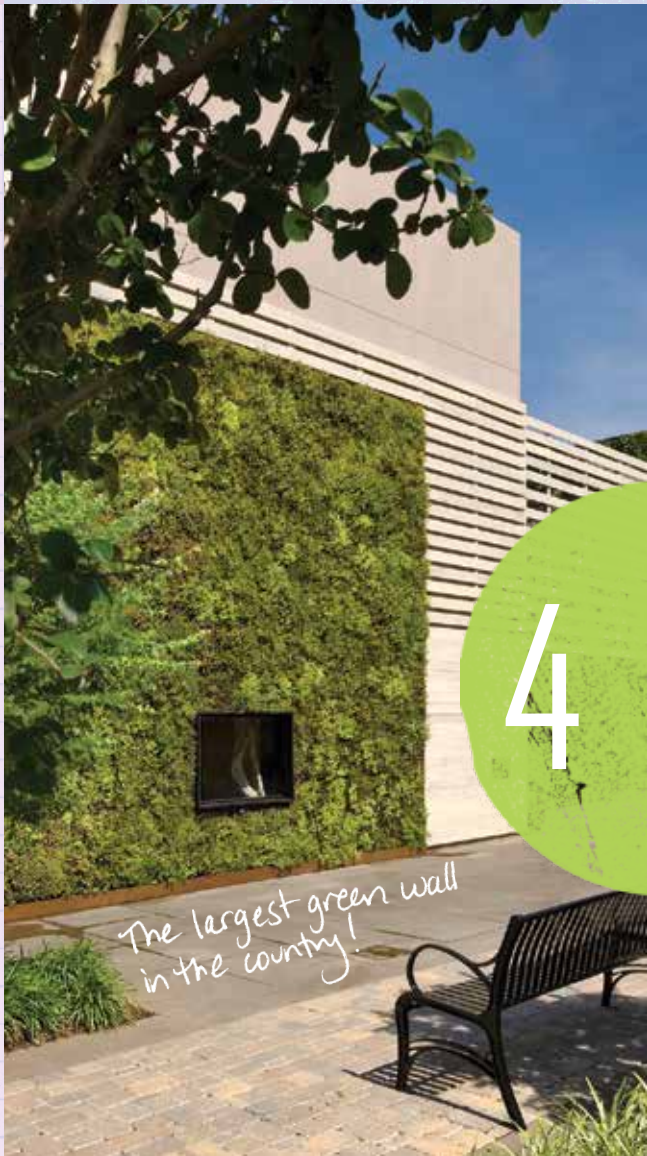
She makes the world a better place by designing innovative farms to feed urbanites.

Courtesy EOA /Elmslie Osler

Robin Elmslie Osler runs her own architecture firm—and uses her skills for more than designing buildings. She and her team dream up green walls and farming systems that fit in and around existing buildings in cities, using natural vegetation to insulate buildings or grow fresh food. Their Urban Farming Food Chain project aims to provide free, healthy food to underserved populations in urban areas across the United States.

This project builds vertical walls that hold approximately 4,000 fruit, vegetable, and herb plants, coupled with kitchen spaces where people can learn what to do with their harvest. The first four food walls were located in the Skid Row area of Los Angeles. "We have the opportunity to change how our cities develop with lasting consequences that will serve future generations in a critical and fantastic way," Robin says.

Robert Reck



Robin designed this green wall for the Hunstville, Alabama, branch of Anthropologie. In the winter, it helps insulate the building to lower energy costs; in the summer, it cools the building by absorbing UV rays.

PHYSICIST

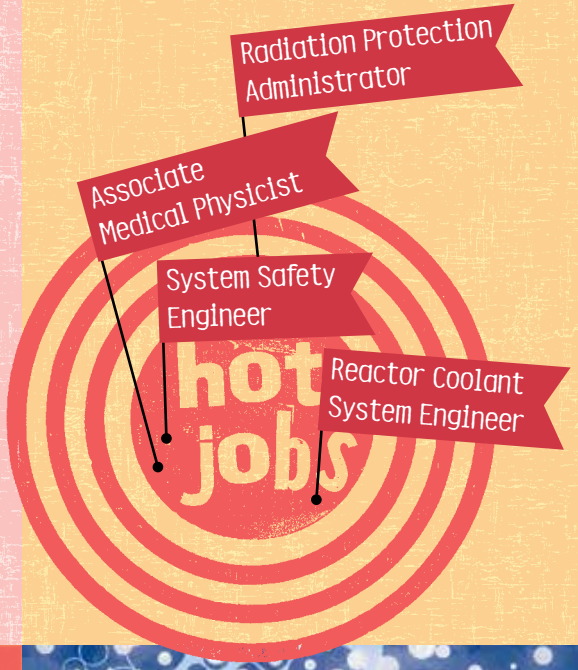
From mapping the structure of atoms to figuring out how gravity affects light in outer space, a physicist's goal is to understand how matter and energy work together. Physicists' deep understanding of energy puts them at the forefront of green technology: Whenever there's a breakthrough in anything, from renewable energy sources to making computers faster, you can be sure a physicist was involved.

As a physicist, you could make the world a better place by…

- Using particle accelerators to smash nuclei, to find new ways of creating nuclear energy without the hazardous waste.
- Designing improved fiber optic network connections to increase downloading and streaming speeds from the Internet.
- Devising a new system for storing nuclear waste that's not only safer but costs the government less money as well.

Average Annual Salary

Starting $58,000
Experienced $85,000



The Quest for Speed

Name Alessandra Lanzara

Job Full Professor of Physics at University of California, Berkeley

She makes the world a better place by finding new ways for electricity to travel.

It all started with roller coasters. "My teacher organized a field trip to the local amusement park as a fun way to learn about fundamental physics in our everyday life," Alessandra Lanzara says. "At the end of the day, I was actually more enthusiastic about the physics underlying the roller coasters than the rides themselves. This is when I decided that I wanted to become a physicist." Today, she works with high-temperature superconductors—new materials that can carry electricity without resistance or loss. "Can you imagine a world like this?" Alessandra asks. "Where we don't have to pay for electricity, where trains can travel as fast as airplanes?"

Imagine Your Environmental Career

Scientists in "green-collar jobs" focus on protecting our planet and the creatures who live on it. They find ways to reduce waste, eliminate pollution, help endangered animals, and improve the processes we use to extract resources from land and sea.

What type of eco-friendly paths might you want to explore? Use the following questions to find environmental challenges that intrigue you. Then look at the chart to see who tackles those challenges.

	YES	NO	Environmental Scientist	Zoologist	Architect	Physicist
1 Would you like to invent a **green-energy device** that collects wind energy and solar energy at the same time?	☐	☐	●		●	●
2 Could you imagine developing ways to use recycled bottles and tires to **build affordable homes?**	☐	☐	●		●	
3 Would you like to **develop an eco-friendly resort** on Australia's Great Barrier Reef that would bring attention to the endangered reef without damaging marine wildlife?	☐	☐	●	●	●	
4 Would you like to **invent a solar cell phone** that needs only 15 minutes of sunlight per day to stay charged?	☐	☐	●			●
5 Would you like to create **spill-proof ways to drill for oil in deep water** that would be safer for ocean wildlife?	☐	☐	●	●		
6 Would you like to create new ways to **capture and dispose of air pollutants** trapped in the atmosphere?	☐	☐	●			●
7 Could you imagine inventing furnaces that heat homes with **geothermal energy** piped from underground?	☐	☐			●	●
8 Could you imagine **attaching transmitters to leatherback turtles** to see if warming oceans are causing them to change their migration routes?	☐	☐	●	●		
9 Would you like to work for NASA on a plan to **knock a giant asteroid off course** if it is heading toward Earth?	☐	☐				●
10 Would you like to help design the next generation of **eco-skyscrapers with rooftop wind turbines** and photovoltaic glass that converts daylight into electricity?	☐	☐	●		●	●

Which scientist might you like to be? (Check one. You'll use this later.) ● ● ● ●

4

First, check off your favorite career from each part on the list. Then, choose one of them and fill in this profile, imagining yourself in that job 15 years from right now.

FUTUREpage

PROFILE | RÉSUMÉ | RESEARCH | TALKS | LINKS

upload photo

Name:

Current career:

Salary:

Education:

My passions:

Honors and awards:

Status update:

Current project:

Recent accomplishments:

What I'd love to work on next:

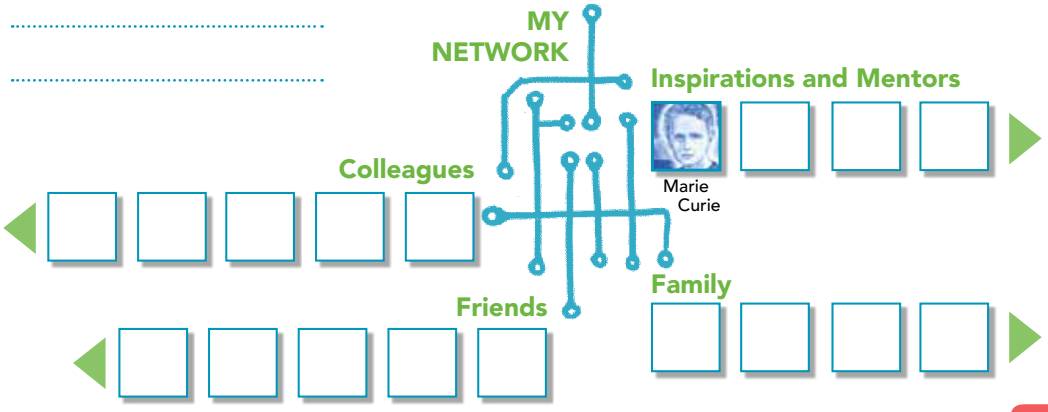
How I've made the world a better place:

1
- ☐ Software Engineer
- ☐ Mathematician
- ☐ Product Designer
- ☐ Systems Architect

2
- ☐ Materials Scientist
- ☐ Biologist
- ☐ Forensic Scientist
- ☐ Food Scientist

3
- ☐ Environmental Engineer
- ☐ Civil Engineer
- ☐ Mechanical Engineer
- ☐ Chemical Engineer
- ☐ Electrical Engineer

4
- ☐ Environmental Scientist
- ☐ Zoologist
- ☐ Architect
- ☐ Physicist



ASK MY ADVICE