Bee a ChemE

An AIChE K-12 Initiative

Bee a ChemE Activity Book

Take the Chemical Engineering Challenges! →

Inspiring the Next Generation to Engineer the Future

Bee a ChemE is an initiative from AIChE, the Global Home of Chemical Engineers, to spark curiosity and empower students to make a positive impact through chemical engineering. Supported by individual donors and corporate sponsors, we're addressing the STEM skills gap, and shaping the future of innovation.

Important Reminder

Always talk to your parents or teachers before starting any of these challenges! Chemical engineers are known for their problem-solving and teamwork skills. Make sure to think through your ideas and encourage others to join in on the fun!

Chemical Engineers: The Superheroes of Science

Chemical engineers are like superheroes—they use science to solve problems and make the world a better place! You are about to explore the amazing world of Chemical Engineering! Get ready to take on fun challenges, solve big problems, and learn how engineers help improve the world around us.

Circle a chemical engineering challenge that you'd like to take on:

- Clean our oceans from pollution
- Create new medicines to help people
- Make renewable energy like solar and wind power
- Design new ways to explore space

Write a sentence explaining why this issue matters.

Word Search

Circle these words as you find them, and read the next page to learn what they mean!

Exchanger
Fluids
Heat Transfer
Process
Reactor
Chemical
Engineer
Scientist
Materials
Recycle
Oxygen
Hydrogen
Sustainable
Biodegradable
Plant
Laboratory
Energy
Filtration
Element
Periodic Table
Carbon
Molecule
Column
Valve

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

Word Search Dictionary

Exchanger: A machine that moves heat or energy from one thing to another, like how a heater warms up your house.

Fluids: Liquids or gases that can flow and take the shape of their container, like water in a glass or air in a balloon.

Heat Transfer: The movement of heat from something hot to something cooler, like when you warm up your hands by holding a hot cup.

Process: A series of steps that change materials or create something new, like baking cookies or building a robot.

Reactor: A controlled environment or vessel where chemical reactions take place to transform substances into different products, often using heat, pressure, or catalysts to speed up the process.

Chemical: A substance that can combine with others to create new materials, like water, which is a chemical made of hydrogen and oxygen.

Engineer: A person who uses math and science to solve problems and build things, like bridges, cars, or machines.

Scientist: A person who studies the world to learn how things work, from tiny atoms to the stars in space.

Materials: The things that objects are made of, like wood, metal, or plastic.

Recycle: Turning old or used items into something new, like melting down old plastic bottles to make cool new toys or clothes!

Oxygen: A gas in the air that humans and animals need to breathe to stay alive.

Hydrogen: A very light gas that helps make water and can also be used as fuel to power things like rockets and cars.

Sustainable: Using resources responsibly so they last for future generations, like using renewable energy or materials that can be reused without harming the planet.

Biodegradable: A material that can break down naturally over time, like a banana peel that turns into soil.

Plant: A large machine or factory where products are made.

Laboratory: A special room where scientists and engineers do experiments and make discoveries.

Energy: The power that makes things move or work, like electricity that powers your phone or the food you eat that gives you strength.

Filtration: The process of removing things from a liquid or gas, like straining pasta or cleaning dirty water.

Element: A basic building block of everything around us, like gold, oxygen, or iron, found on the periodic table.

Periodic Table: A chart that shows all the different elements that make up everything in the world.

Carbon: An element found in all living things, and in materials like coal and diamonds.

Molecule: A group of atoms stuck together, like two hydrogen atoms and one oxygen atom to make water.

Column: A tall, vertical structure in a chemical plant used to separate or process substances by changing temperature or pressure.

Valve: A device that controls the flow of a liquid or gas, like turning a faucet to let water out.

How Chemical Engineers Are Saving Our Planet

Chemical engineers are helping the planet by cutting down on waste and making clean energy like solar power and biofuels.

Imagine this!

You're a chemical engineer and your mission is to develop a new biofuel made from plants that will help reduce pollution and create a cleaner planet. But there's a challenge! You need to decide how to get the plants: Should you use local plants or imported plants to develop your new biofuel?

Option A: Use Locally Sourced Plants

- By using locally grown plants you can support local farmers and reduce emissions from transportation.
- Using native plants can help the environment and ecosystem thrive.

Option B: Use Imported Plants

- Importing non-native plants could potentially introduce an invasive species to your area.
- Introducing non-native plants can sometimes be beneficial to biodiversity in specific situations.

Which option did you choose? Why?

- Write down your choice and explain why you picked that approach.
- How do you think your choice will impact the environment and your community?

Follow-Up Questions:

- What might be some long-term effects on the environment if you choose to use imported plants?
- How could your choice influence how customers view your biofuel? Will it affect its popularity?

Sustainability Tips for Everyday Heroes

Here are some easy ways you can practice sustainability at home—each one is a small challenge that can make a big difference!

Turn off the lights every time you leave a room.

Save water by taking quicker showers.

Recycle everything you can, following local guidelines.

Use reusable bags whenever you go shopping.

How Chemical Engineers Shape Your World

From biodegradable plastic bags to the chips in your gaming console, chemical engineers create so many of the products we use every day. They help design things that make our lives easier, safer, and more eco-friendly.

DIY Time! Make Your Own Biodegradable Plastic.

Plastic is everywhere, but not all of it is good for the environment. Some plastics take hundreds of years to break down. Now you'll be the chemical engineer who finds a solution!

What You'll Need:

- Cornstarch
- Water
- Vegetable oil
- Food coloring (optional)
- A microwave-safe bowl

Instructions:

1. **Mix It Up:** In your microwave-safe bowl, combine 1 tablespoon of cornstarch with 1 tablespoon of water. Add a few drops of vegetable oil and food coloring (if you want to make it colorful).
2. **Heat It:** Microwave the mixture for 30 seconds. Be careful—it may be hot when you take it out!
3. **Shape It:** Once the mixture cools down, you can mold it into different shapes, like beads or small containers. It will harden as it dries.
4. **Test Your Product:** How sturdy is your homemade plastic? Could this be used as packaging for food or toys? Try to imagine what a real chemical engineer would do to make it even better.

Bee-lieve it or Not!

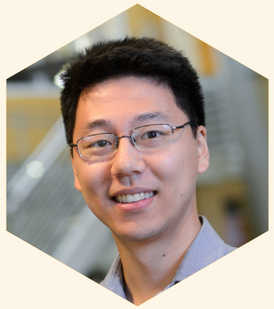
From biodegradable plastics to reusable materials, chemical engineers are working to reduce waste and create packaging that's better for the environment.

Chemical engineers help make food safer by designing packaging that keeps it fresh for longer and developing systems that prevent contamination.

Ever wonder how sports gear is so light and strong? Chemical engineers also design the materials that go into high-performance shoes, helmets, and even bicycles.

How Chemical Engineers Are Using Nanobots to Change the World

Chemical engineers use super tiny robots, called nanobots, to do big things! These nanobots are so small you can't see them, but they can help fight diseases, clean the environment, and even make things like sunscreen and electronics better.



Meet Albert Keung

Q: What do you do as a chemical engineer?
A: I study DNA and how it stores information—kind of like a computer!

Q: What cool things have you worked on?
A: My team and I use nanotechnology to create life-saving medicines and eco-friendly fuels.

Q: How does your work help the world?
A: By changing things on a tiny level, we're solving big problems, like finding new ways to store information and protect the planet.

Bee-lieve it or Not!

Nanotechnology Superpowers

Tiny Cancer Fighters: Nanobots deliver medicine straight to cancer cells without harming the rest of the body.

Water Purifiers: Nanotechnology is used to make filters that clean water, helping people drink safe, clean water.

Invisible Sunscreen: Nanoparticles in sunscreen protect your skin from the sun while feeling light and invisible.

Match the Word to Its Definition!

Remember the words you learned from the word search? Your challenge now is to match each word to the correct definition. Write the letter of the correct definition next to each word.

Words

_____ Exchanger

_____ Hydrogen

_____ Recycle

_____ Engineer

_____ Molecule

_____ Filtration

_____ Periodic Table

_____ Energy

_____ Carbon

_____ Sustainable

Definitions

A. A person who uses math and science to solve problems and build things, like bridges, cars, or machines..

B. A group of atoms stuck together, like two hydrogen atoms and one oxygen atom to make water.

C. A chart that shows all the different elements that make up everything in the world.

D. The power that makes things move or work, like electricity that powers your phone or the food you eat that gives you strength.

E. A very light gas that helps make water and can also be used as fuel to power things like rockets and cars.

F. Turning old or used items into something new, like melting down old plastic bottles to make cool new toys or clothes!

G. A machine that moves heat or energy from one thing to another, like how a heater warms up your house

H. The process of removing things from a liquid or gas, like straining pasta or cleaning dirty water.

I. An element found in all living things, and also in materials like coal and diamonds.

J. Using resources responsibly so they last for future generations, like using renewable energy or materials that can be reused without harming the planet.

Periodic Table Treasure Hunt: Discover the Elements.

Browse the assortment of elements from the periodic table and search for these elements in your everyday life.

Instructions

1. Look around your house and find items that contain elements from the periodic table.
2. As you find items, check them off the list to the right.

Follow-Up Questions:

- Which element was the easiest to find? Why do you think it's so common in our daily lives?
- Which element was the toughest to find and where did you finally find it?

Element Scavenger Hunt List

1. Hydrogen (H): Water
2. Carbon (C): Pencil
3. Oxygen (O): Cloud & air
4. Iron (Fe): Frying pan or cast iron skillet
5. Gold (Au): Gold jewelry
6. Silicon (Si): Hourglass
7. Calcium (Ca): Cheese
8. Aluminum (Al): Soda can or aluminum foil
9. Nickel (Ni): Nickel Coin
10. Chromium (Cr): Silverware
11. Zinc (Zn): Mineral Sunscreen
12. Titanium (Ti): Sporting equipment
13. Lithium (Li): Battery
14. Neon (Ne): Neon Sign
15. Fluorine (F): Toothpaste
16. Sulfur (S): Egg
17. Silver (Ag): Mirror
18. Iodine (I): Fish
19. Sodium (Na): Salt
20. Helium (He): Balloon
21. Potassium (K): Banana
22. Boron (B): Borax (cleaning product)
23. Lead (Pb): weights
24. Magnesium (Mg): Chocolate
25. Tin (Sn): Soup can

Hydrogen ☐	Carbon ☐	Oxygen ☐	Iron ☐	Gold ☐
Silicon ☐	Calcium ☐	Aluminum ☐	Nickel ☐	Chromium ☐
Zinc ☐	Titanium ☐	Lithium ☐	Neon ☐	Fluorine ☐
Sulfur ☐	Silver ☐	Iodine ☐	Sodium ☐	Helium ☐
Potassium ☐	Boron ☐	Lead ☐	Magnesium ☐	Tin ☐

How Bees Chemically Engineer Honey

A collaboration between

Color Me Ph.D

and

Bee a Chem•E

See if you can find your way through the honeycomb!

1 Let's Begin: Collection

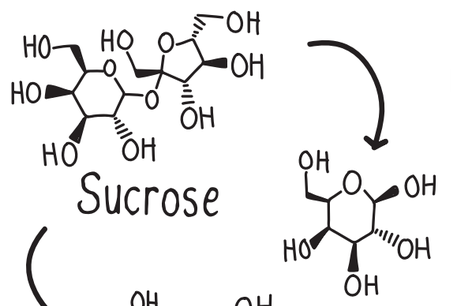
Bees collect nectar, a mix of various sugars, amino acids, proteins, minerals, and other compounds in a water solution.

2 Transportation

Honey bees store nectar in their special honey stomachs.

3 Enzymatic Breakdown

Bees mix the nectar with enzymes in their honey stomach, which break the larger sugars (sucrose) into smaller sugars (glucose and fructose).



4 Continued Processing

Bees pass the nectar to other house bees who further break down the sugars.

5 Deposition

Bees deposit the nectar into hexagonal cells in the honeycomb.

6 Evaporation

Bees fan their wings to reduce the water content of the nectar from ~70% down to ~17-20%.

7 End Product: Honey!

Once the honey is ready, the bees seal the honeycomb with wax.

HONEY

How Chemical Engineers Help Save Lives

Chemical engineers play a key role in making medicines that save lives! They help develop vaccines and treatments for diseases, keeping people healthy. From creating safe ways to deliver drugs to improving how medicines are made, these engineers lead the way in medical innovation.

Bee-lieve it or Not!

Did you know that the word "vaccine" comes from the Latin word for cow, "vacca"?

In 1796, a doctor named Edward Jenner used material from a cowpox sore—what you might call "cow goo"—to protect an 8-year-old boy named James Phipps from smallpox. Jenner wanted to see if exposure to cowpox could create immunity against the more dangerous smallpox. It worked! Thanks to Jenner's discovery and James' bravery, we now have vaccines that protect us from many diseases!

Meet Coloring Book Communicator Julie Rorrer

Q: Growing up, did you always feel drawn to both art and science?
A: I come from a family that values both art and science. My mother and brother are musicians, and my father is a chemical engineer. I've always been interested in art, whether it be playing the violin or doodling in the corner of my notebooks at school to help me connect the dots.

Q: How did you merge your love for art with your passion for science?
A: Back in middle school, I actually worked with my father to create a series of comic strips that explained his research in diatoms, which are single-celled algae that have a glass shell. That helped plant the seeds for what is now ColorMePhD, a line of coloring books that help future scientists understand complex scientific concepts.

Q: What area of chemical engineering are you focused on now?
A: Today, my focus is on heterogeneous catalysis and plastic upcycling—we take plastic waste and waste from plants and break them down through chemical catalysis. Instead of throwing our plastic away into landfills, we can convert it into fuels, chemicals, and other products that we need.

Spot the Difference!

Can you spot five differences between these manufacturing scenes?

Chemical Engineers Are Paving the Way for Space Exploration!

Get ready to blast off! Chemical engineers are using their skills to help us explore space, from building rockets to creating new ways for astronauts to survive on distant planets!

Space Survival Challenge: Creating Water for Mars

Imagine you're a chemical engineer on a mission to Mars! Your job is to ensure astronauts have enough water to drink and use while they explore the planet. Since Mars doesn't have easy access to water, you need to choose the best way to create it.

How will you provide water for the astronauts?

Option A: Extract water from the ice found on Mars.

- **Pros:** There are frozen ice deposits on Mars, so you have a local source to create water.
- **Cons:** You'll need special tools to dig up the ice and then melt it, which can be complex.

Option B: Bring water from Earth in tanks.

- **Pros:** The water is ready to use and easy for astronauts to drink.
- **Cons:** Bringing enough water all the way from Earth will increase the weight of the rocket, requiring more fuel.

What will you choose and why?
Which option do you think is better for long-term missions on Mars? Why do you think that option would work best?

Explore Space Like a NASA Engineer!

NASA's Eyes on the Solar System: Travel through the solar system virtually and explore planets, moons, and asteroids.

Star Walk 2: A stargazing app that helps you identify constellations and planets in real-time.

Mars Rover Simulator: Drive a virtual Mars rover and see what it's like to explore the red planet.

SkyView: Use your phone to scan the sky and learn about stars, satellites, and more in real-time.

Meet Intergalactic Adventurer Joan Melendez Misner

Q: What sparked your love for space?
A: As a kid, I loved using the telescope my mom gave me to gaze at the stars. That curiosity never went away!

Q: What cool projects are you working on now?
A: I'm working on a scientific mission called Dragonfly. This is a planned mission to send a robotic rotorcraft (similar to a helicopter) to the surface of Titan, the largest moon of Saturn. Titan's atmosphere is similar to Earth's, so by studying it, and flying a rotorcraft for the first time, it'll help us understand the origins of life on Earth.

Q: What's your dream for the future?
A: One day, I hope to become a Launch Director and help humanity create a real, sustainable presence on the moon.

Bee-lieve it or Not!

Could Sunlight Fuel Our Space Adventures?

Did you know that engineers are developing a groundbreaking technology called **artificial photosynthesis**? This system mimics how plants use sunlight and carbon dioxide (CO_2) to make energy. Instead of producing food, artificial photosynthesis can turn sunlight and CO_2 into fuels like methane, which is powerful enough to run spaceships. In the future, astronauts might use this method to generate fuel on Mars by taking advantage of its CO_2-rich atmosphere and abundant sunlight. This could pave the way for sustainable space exploration!

How Chemical Engineers Create Your Favorite Lotions and Perfumes

Did you ever wonder who creates shampoos, soaps, and perfumes? That's right. It is chemical engineers ensuring that you smell fantastic and stay fresh!

Create Your Own Custom Lip Balm!

Get hands-on and make your own lip balm using simple, natural ingredients. Here's what you'll need:

- **Coconut Oil:** For moisture.
- **Beeswax:** To give it a nice texture.
- **Essential Oils:** For a touch of fragrance (like peppermint or lavender).

Instructions:

1. Melt the coconut oil and beeswax together in a small pot over low heat.
2. Once melted, add a few drops of your chosen essential oil.
3. Pour the mixture into a small container and let it cool. Voila! You've made your very own lip balm!

Think Like a Chemical Engineer

Imagine This: You are a chemical engineer working in a cosmetics lab, and you're faced with the challenge of formulating a new moisturizer.

The Challenge: You want to create a formula made from natural ingredients, but you know that natural ingredients tend to degrade faster. Before getting your new moisturizer out into the world, it'll have to undergo many different types of tests. If you could choose, which type of testing would you prioritize?

- **Temperature Testing:** Testing the moisturizer by exposing it to different temperatures—cold, warm, and hot—will allow you to evaluate how the emulsion performs under typical storage conditions. Ensuring it remains stable at these various temperatures will give you greater confidence in its effectiveness for your consumers.
- **Light Exposure Testing:** Testing the moisturizer with different light sources, including UV light, will help you determine if any ingredients break down or if the emulsion breaks down when exposed to light over time.

Follow-Up Questions:

1. Which option did you choose? Why?
2. How might limiting our testing to just one factor impact the overall quality and safety of the moisturizer?
3. What are the potential consequences if the product degrades under light exposure, even if it holds up well at different temperatures?
4. Why is it important to understand how these environmental factors interact in our product?

Bee-lieve it or Not!

Did you know that makeup can expire?

Just like fresh food, makeup has a shelf life! It's important to check expiration dates before you buy. Chemists ensure that cosmetics stay stable and safe for as long as possible, making sure you always look your best!

Meet Skincare Superstars Gloria Lu & Victoria Fu

Q: What inspired you to dive into the beauty world?

A: The beauty industry may not be the first place that comes to mind when you think 'chemical engineering'. But it's an exciting place where you can turn your knowledge & ideas into actual products that millions of people use. Our shared passion for product development led to a blog, a podcast, a book, and eventually our own line of skincare products based on sound science. That's the beauty of chemical engineering!

Q: Why is a science background so important in skincare?

A: If you want to formulate better cleansers, moisturizers, and sunscreens, it helps to know your acids from your enzymes! Moreover, the scientific process of hypothesizing, testing, adjusting is essential to perfecting your product creation.

Q: What's your mission for the future?

A: We want to continue to create creative, unique, and highly efficacious skincare products that embody good science and good formulation to help everyone find products right for their particular skin quirk.

Kitchen ChemE: DIY Activities

Ever wonder how chemical engineers use everyday ingredients to create cool reactions? Chemical engineers study how different substances interact, and you can do the same with common items like baking soda, flour, and salt. These simple ingredients are made of elements from the periodic table, and each one has unique properties. Through DIY activities, you'll discover how chemical reactions work—and maybe even create your own mini experiments.

Ice Cream in a Bag!

Challenge: Get ready to unleash your inner scientist in the kitchen! In this cool activity, you'll make ice cream in a bag while discovering the magic of chemistry. As you mix your ingredients and shake the bag, you'll see how salt and ice work together to lower the temperature, turning your liquid ingredients into delicious ice cream. It's a tasty way to explore freezing point depression and how substances combine to create a creamy treat we love!

Ingredients:

- 1 cup half and half or whole milk
- 2 tablespoons sugar
- ½ teaspoon vanilla extract
- 4 cups Ice
- ¼ cup salt (rock salt or table salt)
- 1 quart-sized resealable plastic bag
- 1 gallon-sized resealable plastic bag

Instructions:

1. In the gallon-sized bag, place the ice and add the salt.
2. Place the sealed quart-sized bag inside the gallon-sized bag with ice. Seal the gallon-sized bag tightly.
3. Shake it up! Shake the bags vigorously for 5–10 minutes until the ice cream thickens.
4. Remove the quart-sized bag, wipe off the salt, and enjoy your homemade ice cream. Enjoy!

What's happening?
In this experiment, the salted ice melted faster and became much colder than the ice without salt. This happened because salt lowers the freezing point, making the ice cold enough to turn the ingredients into ice cream. Without salt, the mixture stays liquid. You also created an emulsion, which mixes fat from the cream with water, sugar, and air, resulting in smooth ice cream. This is similar to how salt helps melt ice on roads in winter by lowering the freezing point.

Make a Lemonade Fizzy Drink

Challenge: Become a Kitchen ChemE and create your own fizzy drink! You'll learn about carbonation and flavor mixing while experimenting with different ingredients.

Ingredients:

- Lemon
- Drinking glass
- Water
- 1 teaspoon of baking soda
- Some sugar to make it sweet

Instructions:

1. Squeeze as much of the juice from the lemon as you can into the glass.
2. Pour in an equal amount of water as lemon juice.
3. Stir in the teaspoon of baking soda.
4. Give the mixture a taste and add in some sugar if you think it needs to be sweeter.

What's happening?
The mixture you created should go bubbly and taste like a lemonade, soda, fizzy or soft drink, if you added some sugar it might even taste like a lemon flavored soft drink you've bought at a store. The bubbles that form when you add the baking soda to the lemon mixture are carbon dioxide (CO_2), these are the same bubbles you'll find in proper fizzy drinks. Of course they add a few other flavored sweeteners but it's not much different to what you made. If you are wondering how the carbon dioxide bubbles formed, it was because you created a chemical reaction when you added the lemon (an acid) to the baking soda (a base).

Kitchen ChemE Safety Tips

When conducting experiments in the kitchen, keep these safety tips in mind:

- **Wash Your Hands:** Always start by washing your hands to keep everything clean.
- **Adult Supervision:** If you're using the oven or sharp utensils, make sure an adult is nearby to help.
- **Follow Recipes Carefully:** Measure ingredients accurately and follow instructions to ensure a successful experiment.
- **Stay Clean:** Keep your workspace tidy and clean up spills to avoid accidents.

We hope you keep exploring the wonders of chemical engineering!

AIChE
The Global Home of Chemical Engineers

DOING A WORLD OF GOOD

Thanks to our partners for their support in inspiring the next generation to engineer the future and explore the possibilities of a career in chemical engineering.

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