Core Knowledge® SCIENCE

# Chemical Reactions and Energy:

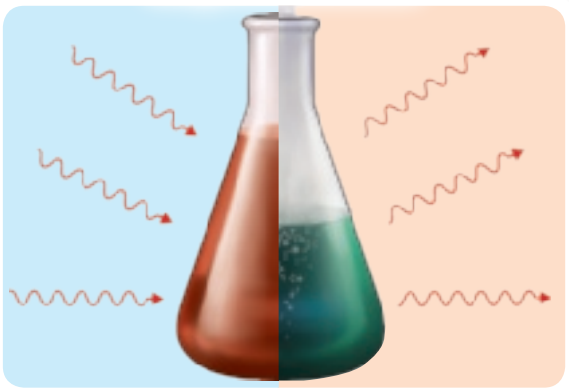
## How can we use chemical reactions to design a solution to a problem?



Science Literacy

**Science Literacy Student Reader**

Energy in a chemical reaction






Chemically activated hand warmers



Chemical heating of food

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# Chemical Reactions and Energy

## Science Literacy Student Reader



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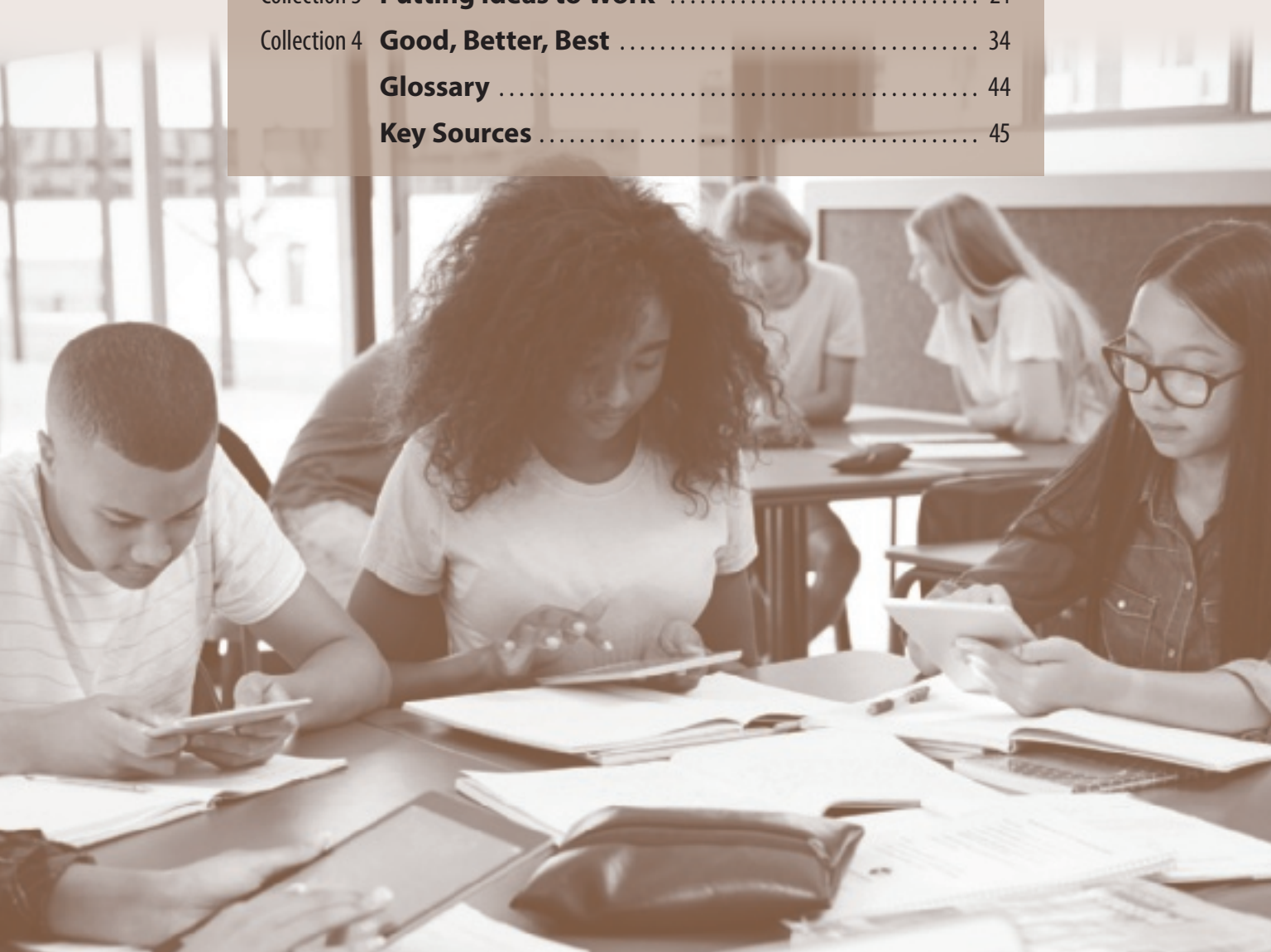
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# Chemical Reactions and Energy

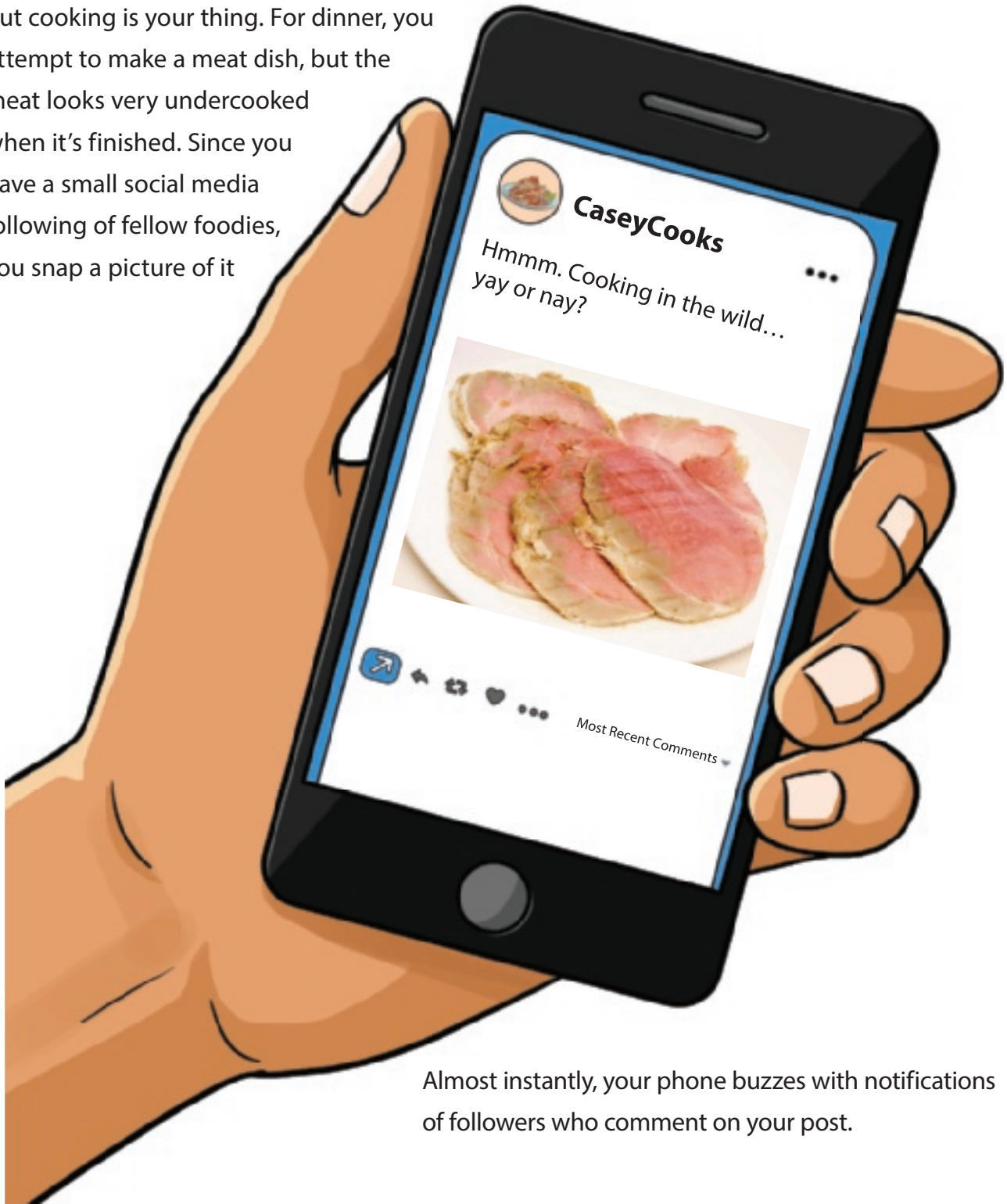
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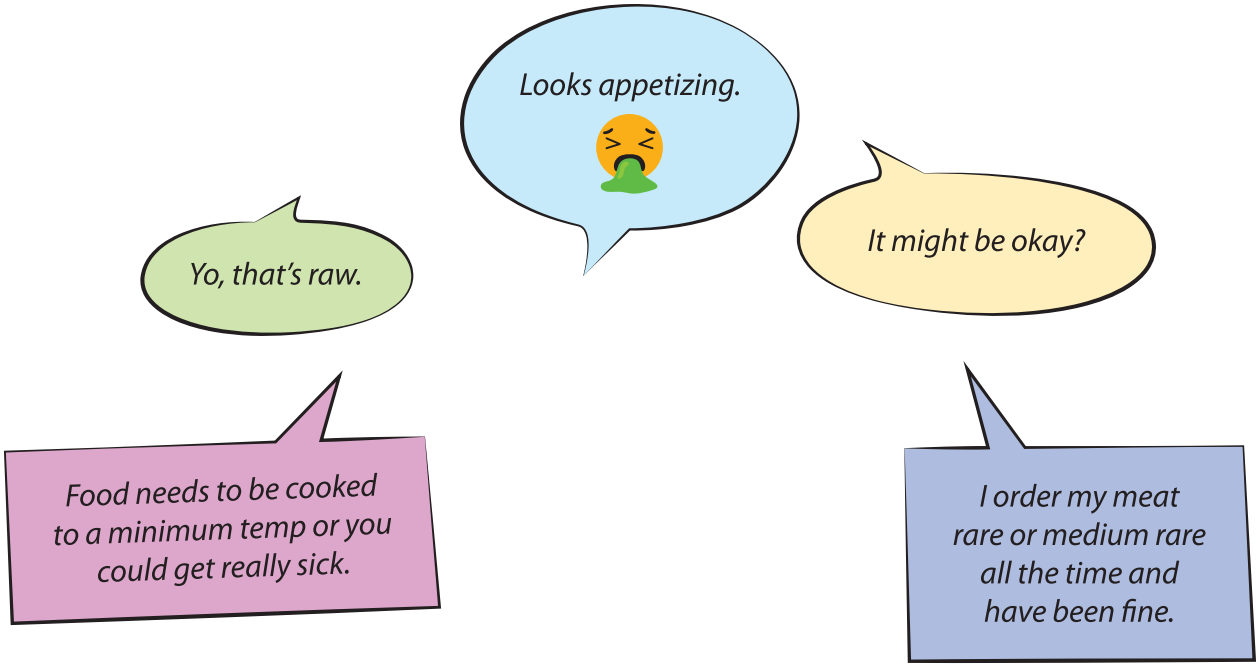



# Put Yourself in This Scene

Imagine you are camping with a friend. You bring along a new flameless heater so you can cook food while at the campground. Sure, you could eat tin cans of food instead, but cooking is your thing. For dinner, you attempt to make a meat dish, but the meat looks very undercooked when it's finished. Since you have a small social media following of fellow foodies, you snap a picture of it and post it to your page. You know something doesn't look quite right, but you're curious what others will think or suggest.




Almost instantly, your phone buzzes with notifications of followers who comment on your post.




You show the comments to your friend. Your friend says that the meat is probably fine because you followed the instructions that came with the flameless heater.

It's a good point. But still, something inside of you gives you pause. The comments on your post were from your followers. You want to believe them. But maybe they don't really know for sure. Are they a credible source? You also want to believe your friend.

That's what this book is about—scientific literacy, which means knowing how to think about science topics that you read or hear about. Our world has 24–7 news, social media, and too many websites to count. The amount of information we have to sort through is overwhelming, and all the information is not reliable. In the internet age, sources of information are often obscure or not trustworthy. It is good to process information with a healthy degree of skepticism.

We will make our way back to this food safety topic by the end of the book. Along the way, the series of reading selections and the writing exercises that go with them will help you flex your mental muscles and sharpen your science literacy skills. The ability to read about science, understand the information, and tell truth from fallacy or misrepresentation is really important. Science literacy helps you as an individual and as a consumer, and it shapes the ways you affect the community in which you live.

# What's Cooking?

Remember your last car trip? You may have packed yourself some snack foods for the ride in case you got hungry. These foods were probably easy to access and simple to eat, like sandwiches, chips, and granola bars. After all, it would be dangerous to get out a burner and start cooking raw food over a hot flame while riding in a car. Apart from car trips, there are several scenarios in which having prepackaged meals on hand is helpful or even essential for survival.

### Military

Military personnel in the field must eat. Because of their unique conditions, they must travel light, have food containers that will not leak or puncture, and be able to consume food quickly and easily, while getting enough calories to meet their energy needs. The Department of Defense adopted the Meal, Ready-to-Eat (MRE) as the official food ration in 1975. MREs are single-serve meals in sealed pouches. The pouches contain a variety of calorie-packed foods. Meats are precooked, but many must be heated before they are consumed. MREs come with flameless heaters that rely on **chemical reactions** to warm the meals. Examples of such meals include beef stew, chicken in Thai sauce, and spaghetti with meat sauce.



## Vocabulary

**chemical reaction, n.** a process that involves converting one or more substances (the reactants) into one or more other substances (the products) by rearranging their atoms

## Connection

If a tortilla stuffed with vegetables and meat is one of your favorite foods, you're not alone. Tortillas are also one of the favorite foods of astronauts! Sandwiches made with sliced bread produce crumbs that could float around the spaceship in low gravity. Tortillas don't have that problem.

## Word to Know

To *reconstitute* food means to restore the food to its original form by adding water to it.

## Astronauts

The food astronauts bring to outer space must meet certain criteria, but it also must be appetizing. The food, containers, and packaging need to be lightweight because of spacecraft weight limitations. Astronaut food must have a long shelf life and be safe to eat, meaning bacterial growth is not a threat. Space ovens are being tested, but for now food must not need to be cooked. The most suitable types of prepackaged food for astronauts to take into space are freeze-dried, heat processed and sealed, or ready to eat without preparation, such as nuts and granola bars.



## Disaster Relief

Natural disasters happen. When they do, it is critical that victims of these unfortunate events have their basic needs met to survive, including food to eat. In emergency situations, such as hurricanes, floods, freezes, and earthquakes, people may not have access to cooking equipment or even electricity. Prepackaged foods, like MREs and canned foods, can be delivered and distributed in these affected areas so people can have nutritious, calorie-dense meals.



## Outdoor Adventures

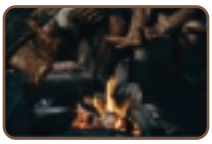
People who hike to extreme elevations, scale mountain walls, climb up rocky cliffs, or run hundreds of miles often need to carry their food on their backs. Having prepackaged food is necessary for outdoor extremists. Weight and space are issues, as these individuals can only pack so much with them. The food must also be easy to consume.



# Food for Thought

**#fireforfood** That could have been the hashtag for life for early humans. Scientists believe our ancestors began heating food with fire at least 400,000 years ago. Using fire to cook food revolutionized the way our ancestors lived and developed. It gave them more choices for what they could eat.

There are many benefits to heating food. For one, heating food helps predigest it so our bodies 1) spend less time breaking it down, 3) can absorb more of the nutrients, and 3) can therefore extract more fuel for our bodies and brains to use. Food gets softer as it heats up, which makes it easier for us to chew. And, most of all, heating food kills off bacteria that could make us sick.



**400,000 BCE:** Fire Cooking

They didn't have fancy barbeque grills, but humans cooked food over open flames, and this made it easier to chew food, killed off harmful bacteria, and paved the way for new foods to be eaten.



**2400 BCE:** Pickling

People discovered that foods could be stored and eaten later when vinegar or brine was poured over them. Today, cucumbers are probably the most familiar pickled food, but lots of foods can be pickled. The vinegar or brine acts as a preservative. It changes the consistency of the foods that are pickled, often softening them and making them more bitter. The earliest pickled foods were sometimes kept in dark storage conditions or even buried underground until they were ready to be eaten.



**600 CE:** Jam Preparation

In Greece, people came up with a method of using honey to make fruity jam. Quinces, a type of fruit, would be cut up and put into jars. The honey was then added to them. The honey softened and sweetened the fruit over time, thus acting as a preserve. People placed them into jars that were tightly sealed so that the fruit stayed tasty and safe to eat for a while.

**5000,000 BCE**



**12,000 BCE:** Sun Drying

Food contains water, and moisture creates an environment suitable for microbe growth. Sun drying was an early food preservation method that involved laying vegetables, fruits, noodles, meats, and other foods out in the sun to dry. This reduced microbe growth and prolonged the food's shelf life by removing water from it. However, sun-dried foods were tougher and harder to chew and digest.



**360 BCE:** Curing

Pass the salt! Curing means adding salt to foods to prevent spoilage. But not just a sprinkle of salt. Lots and lots of salt is added to foods for curing. This method was particularly used for meats. The salt acts as a preservation mechanism and is sometimes considered one of the early forms of "food additives." Meats were often smoked or grilled after being cured.

Cooking is a food preservation method. Most pathogens that could cause foodborne illnesses are killed at temperatures around 100 degrees Celsius. The idea of making foods safer for humans to consume meant that fewer people would fall ill and that more people would benefit from the nutrients they gained from a wider variety of food products. Cooking with fire paved the way for other types of food preservation methods to take shape.

## Connection

Not all bacteria found in foods are bad. Probiotics are friendly bacteria that live inside your body and help keep you healthy. They can perform a range of functions, from helping you digest food to destroying cells that cause diseases. Probiotics are often found in yogurt, kefir, sauerkraut, tempeh, kimchi, and kombucha.



### 1809: Canning

French inventor Nicolas Appert discovered that he could prevent food spoilage if food was tightly sealed in bottles. Sometimes these bottles were heated after they were sealed to kill any bacteria. Appert later produced canned foods for use by the French military. These foods did not necessarily have to be heated before they were eaten.



### 1945: Vacuum Sealing

German inventor Karl Busch came up with a process for vacuum sealing food, which extended its shelf life by removing oxygen within the food's packaging. Without oxygen, bacteria cannot grow or survive. Vacuum-sealed foods were easier to store and transport because they were less bulky than cans. Soldiers in World War II were given vacuum-packed foods because they were easy to carry and consume.

2000s



### 1800s: Cooling and Refrigeration

Evidence suggests that our prehistoric ancestors used ice and snow to slow the spoilage of food. This was especially important for meat since cold temperatures slow down microbe activity. The first cold storage technology was developed in the early 1800s with the invention of the icebox. The earliest iceboxes were wooden chests with separate compartments for food and blocks of ice. The melting ice cooled the food. In 1913, the first electric refrigerator was produced, which changed the way people stored and shopped for food.



### 1871: Pasteurization

French chemist Louis Pasteur had a goal to make milk safer to drink. Raw milk contained bacteria that often made people sick. Pasteur came up with the method of pasteurization for briefly heating milk at a high temperature to kill unwanted bacteria. This made milk safer to drink and also gave it a longer shelf life.



### 2000s: Chemical Preservatives

Today, the food industry often uses chemical preservatives to keep foods fresher for longer and prevent spoilage by reducing chances of microbial activity. These foods rely on chemical additives instead of fire, heat, or other means for making them safe to eat.

# Military Memoir: MREs

Mail ▾ More ▾

COMPOSE

Inbox

Starred

Sent Mail

Drafts

All Mail

More ▾

Inbox X new X new X

**Major General Rivers** <majorgeneralrivers@mmail.com>

**From:** Gerome Harris

**To:** Frank Rivers

**Subject:** School Project: MREs in the Military

Dear Major General Rivers,

It is an honor to email such a distinguished and decorated veteran U.S. general. Thank you for your service to our country.

Our school is in your hometown in Oklahoma, and my classmates and I are working on a science project that explores how MREs work and their application in the military. We were wondering if you would be willing to write to us about your personal experience using MREs. Specifically, we are wondering what the pros and cons of them are, but any information you would like to share would be greatly beneficial!

Thank you sincerely for your time and consideration. We'll be certain to thank you in the class's final science presentation as well.

Warmest regards,
Gerome Harris




**MREs are rationed and distributed to soldiers in combat.**

## Consider the Source

Do you consider the major general a credible source for discussing the pros and cons of MREs? What does he write in his email that makes him credible or not credible?

Mail

More

COMPOSE

Inbox X new X new X

Inbox

Starred

Sent Mail

Drafts

All Mail

More

**Harris** <harris@okschoolmail.edu>

**From:** Frank Rivers

**To:** Gerome Harris

**Subject: Re:** School Project: MREs in the Military

Dear Mr. Harris,

Thank you for contacting me with your questions about MREs. Our hometown in Oklahoma is a small one, but it's the best little town there ever was. And I'd do anything to help out a fellow resident at the school there.

With over 30 years in active service, I can say with much confidence that there are benefits to MREs. First, they are lightweight. That's crucial for people in the military. We carry a lot of equipment on our backs, and we often have to move swiftly. We can't sacrifice space and weight for heavy or bulky foods. The MREs we had were also packaged well. This meant our food would never spill or leak into our backpacks. Our backpacks get tumbled and thrown around a lot, and we can't risk skipping meals because the MREs accidentally got punctured.

My soldiers and I were always grateful for a warm meal. It reminded us of being back home, eating at a restaurant, being on a camping trip with buddies, or being anywhere other than in the middle of a war zone. On cold nights, it warmed us up. On long nights, it gave us comfort. There's just something about a warm meal that beats eating a cold peanut butter sandwich or protein bar (though we ate and appreciated those, too).

As thankful as we all were for MREs, the biggest complaint I heard among my soldiers was that the MREs were sometimes confusing to use. We often ate in the dark and would spend valuable time fumbling with the packets before we were able to get any food into our mouths. The food was quick to heat up, but it didn't stay warm for long, especially in chilly weather. Flameless heaters are nothing like having a real campfire to warm your food.

As a major general, I was privy to some of the operational tactics that went into ordering the MREs, rationing them, and distributing them. Sometimes there were delays with the orders or shipments. Other times the MREs for one troop would be delivered to another troop by mistake. A lot of resources and effort went into tracking the MREs and making sure they were rationed correctly and went to where they needed to go.




I hope this information helps with your science project. Please let me know if I can answer any more questions. I enjoy being able to share my experiences, and it's been an honor to defend our country.

Sincerely,

Frank Rivers, USMC Major General, retired

P.S. For an added trip down memory lane, I am enclosing a picture of a WWII historic poster. MREs are an improvement from what soldiers in earlier years had!

# Winter Ritual

If you've been following my blog for a while, you know that it's almost time for my annual cross-country skiing trip, a winter ritual each January. (And if you're new here, welcome!)

My family and I head out to Quebec—the very best place in Canada for cross-country skiing.

When it's time to hit the trails, we go out there for hours, so it's imperative for us to have a huge breakfast and be ready with anything we might need in the middle of the beautiful nowhere. When I first started this sport, I had the best trail manager in the world. She taught me everything, but there's one thing she left out: how to keep your hands and feet warm!

I never leave our cabin without at least a dozen packs of warmers in my backpack. They're small and lightweight, so they're easy to carry with me on the trails.

There are different brands and types of hand and toe warmers, but all of them are mostly made with the same ingredients: iron, water, salt, activated carbon, and vermiculite. Oxygen in the air activates the chemical reaction that produces heat. Well, let me back up. The heat isn't really created. It's just released by the reaction. What is being made from air-activated hand and toe warmers is rust. Yes, rust. The brown stuff you get on your bicycle if you leave it out in the rain over time.

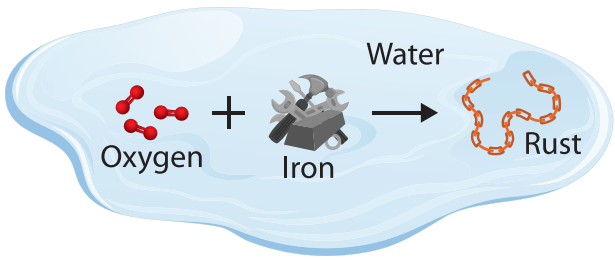


The chemistry of hand and toe warmers is fascinating. When the warmer is removed from the packaging, air enters tiny holes in the pouch. Oxygen in the air reacts with the iron and the water. This process of oxidation creates rust and releases heat.

So then what's the salt for? Well, the salt helps speed up the oxidation and heating. Trust me . . . when you're hours into a cross-country ski trail in freezing temperatures, you want to start feeling the heat pretty darn quickly.

The charcoal has an interesting role. It stores bits of water needed for the reaction with iron. The vermiculite acts as an insulator. Perhaps its most important job is to make sure the warmer does not burn all at once and eat through your hands and toes (yikes!).




## Connection

Vermiculite is a mineral that expands when heated. It is often used in horticulture to retain moisture and nutrients in soil and plants. It is nontoxic, has a neutral pH, and does not rot or get moldy. People sometimes add it to soil to improve the quality for gardening, such as when the soil is too sandy or contains too much clay.

## Dig into Data

Rusting is an oxidation-reduction (redox) reaction. Oxidation is the loss of electrons, and reduction is the gain of electrons. When rusting occurs, the oxidation states of the atoms change at the same time. The chemical formula for rusting is shown as follows:

$$4Fe + 3O_2 \xrightarrow{H_2O} 2Fe_2O_3$$

where Fe is iron, $O_2$ is oxygen gas, and $Fe_2O_3$ is rust. The entire process occurs in water, $H_2O$.

Among which particles does the reduction and oxidation occur?

# Hot Hands for Sale!

**BEST hand warmers**

Seller: **Private, Milford, MI**

★★½☆

(18 reviews)

Hand warmers—Moving from Michigan to Nevada, so no longer need these. They warm up instantly and can stay hot for up to 24 hours—enough to keep you warm through the blustery days and nights. Don't want to use up the heat all at once? You can cut off their warming mechanism by pouring some water on top. Then, when you are ready to use them again, give them a good shake and restart the chemical reactions. That's what makes this brand of hand warmers the absolute best!

These hand warmers usually cost at least $30.00, and if you try buying them online, you will have to order a bulk supply. I'm offering 10 pairs of them at a discounted price simply because I won't need them anymore. Now that's a bargain! The packs in this box have not been used, but one pack accidentally got pierced when I unboxed them. I am not 100% sure that that pack will still work, but you can give it a try. The lot itself is from 2008, but hand warmers do not expire. So whether you need them this winter or next, they will be good as new.




Buy Now

Make Offer

Save to Wish List

## Spot the BS

Heads up! There's some bad science on this page. Can you detect which ad is making questionable claims? Which seller do you have more confidence in?

**Sale on Hand Warmers**

Seller: **Trek-and-Trails Outdoor Supplies, Buffalo, NY**

★★★★

(910 reviews overall)




Come to Trek-and-Trails Outdoor Supplies this weekend, and enjoy our seasonal sale on winter gear. Our hand warmers must go! Our in-stock supply has a shelf life of four years, which means if you buy these today, you can still get two winters out of them before they expire! Whatever type of winter adventure-seeker you are—whether you are climbing, skiing, trekking, running, canyoning, or camping—hand warmers are an essential cold-climate staple.

These disposable hand warmers use an exothermic chemical reaction to warm instantly in the palms of your hands and are meant to be discarded after the warmth wears off. They can stay at peak warmth for about two hours, which is enough time to warm your hands and get them feeling relaxed again. These packs are completely safe. The ingredients remain inside thick, flexible pouches, so there is no risk of leakage inside your backpack. Our hand warmers come straight from our distributors with a manufacturer guarantee. This listing is good for one 10-pack of unused, unopened hand warmers. But hurry, because they won't last long, and neither will our sale!

**Buy Now**

**Make Offer**

**Save to Wish List**

## Consider the Source

The advertisements on these two pages feature hand warmers and descriptions from two different sellers. What can you infer about the two different sellers based on the seller info boxes and the way their ads are written?

# Exothermic and Endothermic Reactions

## Exothermic Reactions

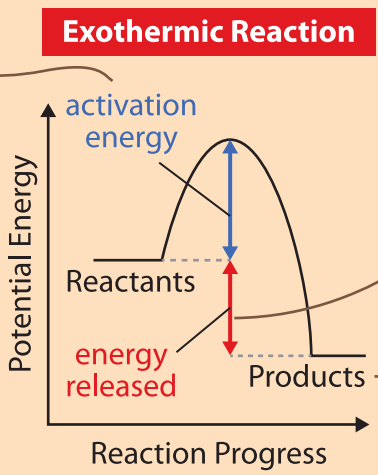
An **exothermic reaction** is a chemical reaction in which energy is released in the form of heat and/or light. The release of energy during these reactions can make the surroundings feel warm or hot.



The warmth of a campfire, the light from a candle, and the launch of a rocket are examples of heat from exothermic reactions.

### Reaction Profile

The activation energy is the input of energy that starts the reaction.




The amount of energy released by the reaction is the difference in the energy of the reactants and the products.

The energy of the products is less than the energy of the reactants.

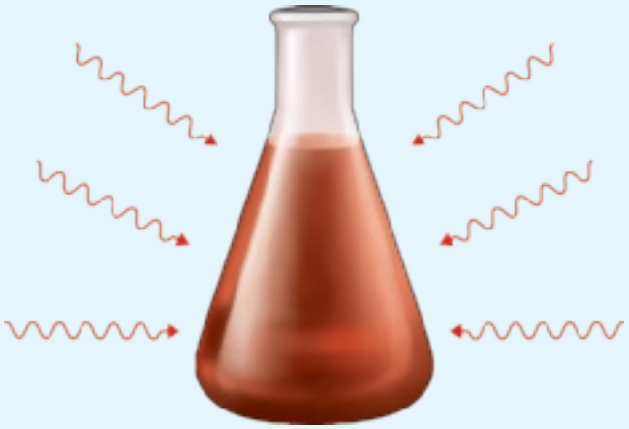
### Words to Know

A *reactant* is a substance in the system at the start of a chemical reaction.

A *product* is a substance in the system at the end of a chemical reaction.

## Endothermic Reactions

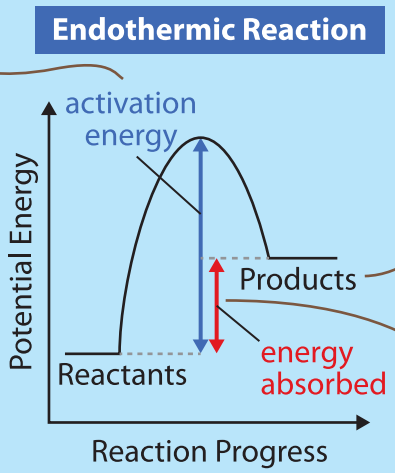
An **endothermic reaction** is a type of chemical reaction in which energy is absorbed. The absorption of energy during these reactions can make the surroundings cooler.



Photosynthesis and cooking an egg are examples of endothermic reactions.

### Reaction Profile

Both endothermic and exothermic reactions need an input of activation energy to get started.




The energy of the products is greater than the energy of the reactants.

The amount of energy absorbed by the reaction is the difference in the energy of the products and the reactants.

### Vocabulary

**exothermic reaction, n.** a chemical reaction in which energy is released

**endothermic reaction, n.** a chemical reaction in which energy is absorbed

# Chemistry Club

| ✉ Exothermic Reactions | Forum. | Posts. | Last Post: |
|---|---|---|---|
| The chemistry of exothermic reactions. | | 71 | 10-09-21 by CoolChem |

| Author | Subject: Exothermic Reactions Are All Around Us | posted on |
|---|---|---|
| ErnieExo | Anyone want to chat about the exothermic reaction experiment we did in chemistry class last week? | 10-08-21 |
| Babss | I'm just amazed that exothermic and endothermic reactions are happening around us, like all the time. | 10-08-21 |
| GuitarGoose | You really think they are happening all around us? Like what? | 10-08-21 |
| CoolChem | Using hot packs, lighting candles, and rust forming on iron are other exothermic examples, just to name a few. | 10-08-21 |
| Babss | I used hot packs a few times when I sprained my ankle. And I light candles. AND my bike has a ton of rust on it. 🙁🙂 | 10-08-21 |
| PaulineL | The rusting one has me a little stumped. Can someone explain that a bit more for me? I get the lighting of candles because heat is released when the wax burns. | 10-08-21 |
| CoolChem | Rusting is caused by oxidation, and heat is given off in that process. | 10-09-21 |
| PaulineL | But the rust on my bike isn't hot… ? | 10-09-21 |
| CoolChem | The rust itself won't be hot. But the reaction involved in rusting gives off heat. | 10-09-21 |

| Author | Subject: Exothermic Reactions Are All Around Us | posted on |
|---|---|---|
| RachLSciFi | Late to the convo…just jumping in here and reading all your comments. I have another cool example of an exothermic reaction to add: setting cement! | 10-09-21 |
| GuitarGoose | Of course, duh. 🙄 LOL | 10-09-21 |
| RachLSciFi | No, really. Think about it. Cement is mixed with water, right? As the cement hardens, some of the water chemically combines with the cement. Heat is released, so it's an exothermic reaction. | 10-09-21 |
| Babss | You should get bonus points for coming up with that one! It would have never occurred to me. | 10-09-21 |
| SmarteePants | Let's take a class poll: Is baking a pizza an exothermic reaction or an endothermic reaction? (Currently craving pizza.) | 10-09-21 |
| Babss | Exothermic! | 10-09-21 |
| CoolChem | Endothermic, for sure. | 10-09-21 |
| RachLSciFi | I'm leaning more toward endothermic. But idk. | 10-09-21 |
| PaulineL | It's exothermic because heat is released by the oven. And because the pizza is hot. | 10-09-21 |
| CoolChem | It's true that heat is released by the oven. BUT heat is absorbed by the pizza dough. That's what makes the food cook. The heat being absorbed in it. So it's endothermic. Well there must be a lot of reactions happening when a pizza cooks, and most of them require heat. 🍕🙂 | 10-09-21 |
| PaulineL | Makes sense! | 10-09-21 |



# Michigan Homes and Land Newsletter

## Thawing Out Ice Melt Myths

Another Michigan winter is approaching us. We all know the drill. A few weeks into November, we stock up on canned goods, buy jugs of water, test our generators, and purchase products for melting snow and ice in our driveways. Time and time again, we have power outages and snow days. Then there are the days we *wish* we were off from work or school because there's so much snow in our driveways that it's impossible for us to get out.

I've been a home real estate agent in Michigan for 23 years, and every year homebuyers ask me how to tell if a driveway is in good condition due to the use of ice-melting products. The shared concern among my homebuyers is that ice melting products damage the surfaces they come into contact with. It's a reasonable concern, especially for homebuyers who are coming from out of state and are unfamiliar with how these products work. So I decided to dedicate this month's newsletter to thawing out the ice melt myths once and for all.



Let's start by discussing ice-melting products. They consist of different blends of salts, with calcium chloride as the star ingredient. They help melt the ice quicker than the time it would take for the ice to melt naturally. This is important because we usually need to get rid of the ice "now" and not "several days from now." Some products are fast-acting. Others are long-lasting. Some can be sprayed instead of sprinkled, and others turn colors when they hit the ice for easy visibility. In the end, all of these products use an exothermic reaction to melt ice quickly (or prevent ice from forming in the first place).

An exothermic reaction gives off heat. When calcium chloride contacts water, it undergoes a chemical reaction that releases heat. This heat then melts the ice.

It makes sense for homebuyers to be concerned with the integrity of the driveway, especially as it relates to ice-melt salts. It is not, however, realistic to think that the chemicals from ice-melting products seep into the porous driveway, lurking and waiting to cause damage over time. That's not how these products work.

Let's thaw the icy myths once and for all: Ice-melting products do not damage driveways. In fact, these products hardly even come into contact with the surface of the driveway. A brine forms on the surface of the ice (and the ice is on top of the driveway). Sure, some of the salt product could touch the driveway when you are scattering it around. But overall, these salts will not have a negative effect on the cement itself. The exothermic reaction involved in melting ice with salt takes place between the salt and the ice, not between the salt and the cement.

Here's hoping all of you out there have a warm and safe winter season!



**Calcium chloride is the main ingredient used for thawing icy roads and driveways. It creates an exothermic reaction when mixed with water.**



**Snow can be plowed or shoveled away from roads, but it is difficult to crack ice to break it free from a surface. Salts are used to dissolve ice more quickly.**

## Consider the Source

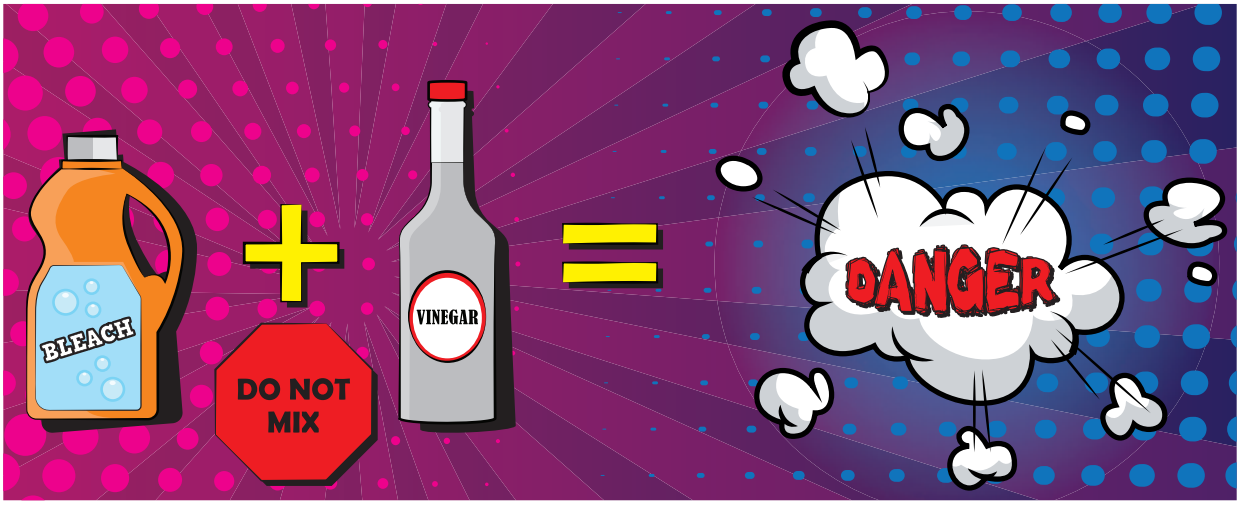
This article was written by a real estate agent who sells houses. What about the author makes them a credible source for information about ice-melting products and the condition of driveways?

# Never Mix These Chemicals

We all want to clean and disinfect our homes regularly to kill unwanted viruses and bacteria. It can be tempting to try out different cleaning chemical combos to make your own super-strength solutions, but . . .

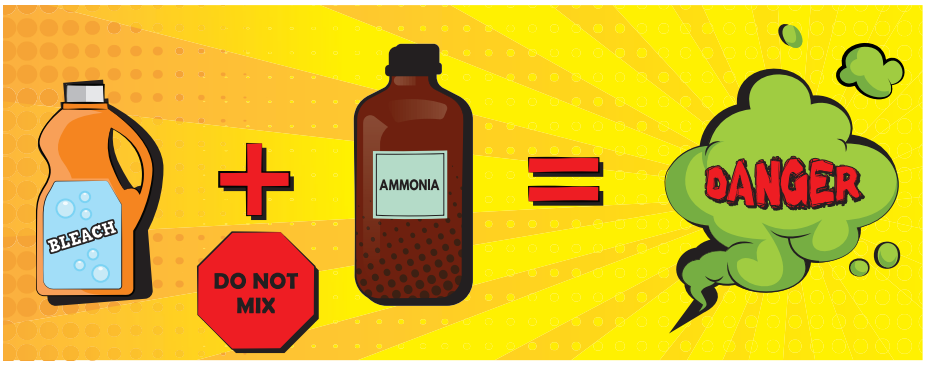
It can be dangerous—even fatal!—to mix certain chemicals together due to the exothermic reactions that can occur as a result. While commercial cleaning chemicals are safe to use on their own, when combined with the wrong solutions, things can go sour very quickly.



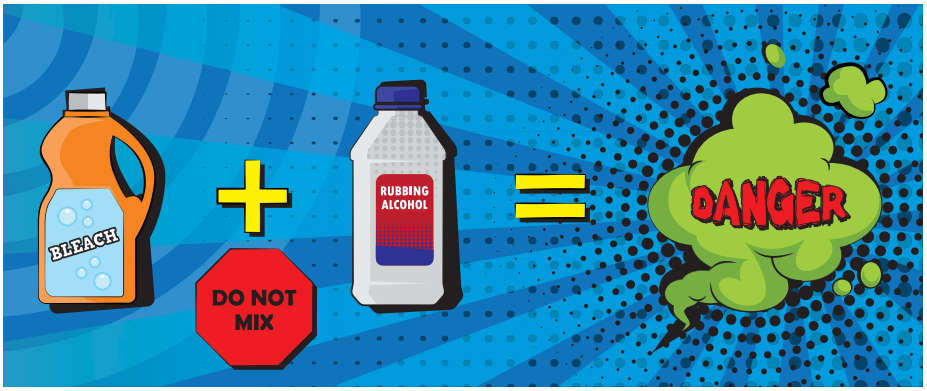




Bleach and vinegar are two common household cleaners. Used separately, they can be very effective at ridding your house of germs. But when mixed, these chemicals produce chlorine gas. If you come into contact with chlorine gas, it can make you cough, make breathing difficult, and burn your eyes.

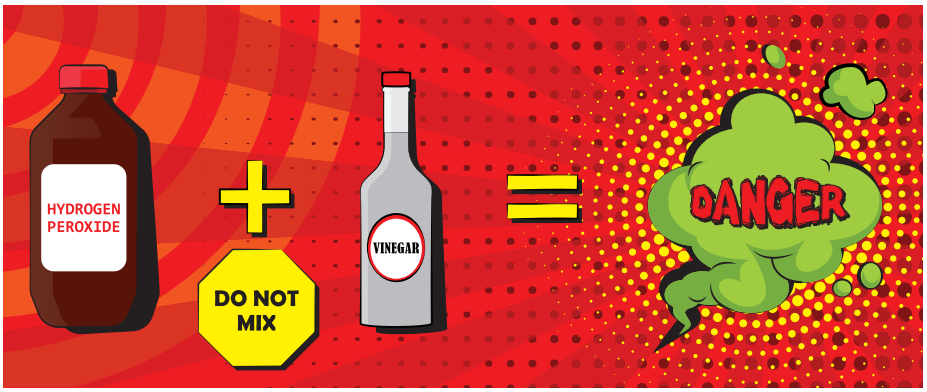
When you mix bleach and ammonia, you get a toxic gas called chloramine. Chloramines on their own may not pose as much of a health threat. In fact, chloramines are used as disinfectants to treat the water that you drink. However, chloramine gas is very dangerous. It can cause shortness of breath, chest pain, burning in the eyes and lungs, and even death if inhaled at high doses.




When you combine bleach with rubbing alcohol, you get chloroform. This product can cause severe problems if you inhale it, get it on your skin, or accidentally ingest some of it. In other words, you do not want to come into contact with this chemical. It can lead to heart problems, nervous system dysfunction, and other impairments.




If you've ever gotten a scrape, you may have poured hydrogen peroxide on it to clean out any germs. Vinegar is often used for cleaning and cooking. Separately, both chemicals are safe to use, but a mixture of them can be very corrosive. Unlike the other dangerous chemicals mentioned before, this mixture is more harmful when it is touched rather than inhaled. Combining hydrogen peroxide with vinegar makes an acid that is often used to sanitize medical or food processing equipment. In all of its applications, the acid is only handled by professionals trained to use it safely.



# The Exo Expo

The Modern Gallery of Art and Science welcomes you to experience the work of some up-and-coming artists in our latest exhibition: The Exo Expo! This brochure is your guide to the art pieces in this dynamic gallery of works inspired by exothermic reactions. We are proud to bring this amazing collection to you and hope that you will join us in experiencing the exhibit in person.

## The Colors of an Exothermic Reaction



This vibrant piece depicts the temperature changes involved in an exothermic reaction, with red, orange, and yellow representing increased heat and light. The artist incorporates a small amount of blue in the space to the left, symbolic of the coolness that exists prior to the reaction.

*Technique: Acrylic on Canvas*

*Artist: René Thompson*

## The Life and Death of Iron Chlorine



In this beautiful painting, the iron-chlorine exothermic reaction is dancing inside a glass cylinder. Our eyes are immediately drawn to the focal point, the bright flame inside the glass, which tells a story about a fiery reaction, while the smoke at the top serves to remind us of the significance of released energy during a chemical reaction.

*Technique: Metal Print*

*Artist: J. J. Graham*

## Element of Life



Water is the "element of life." In this symbolic painting, water gives off a violent reaction when added to potassium. The exothermic reaction produces the gases hydrogen and potassium hydroxide. Allow yourself to be mesmerized by the depth of the texture and movement in this painting.

*Technique: Acrylic on Canvas*

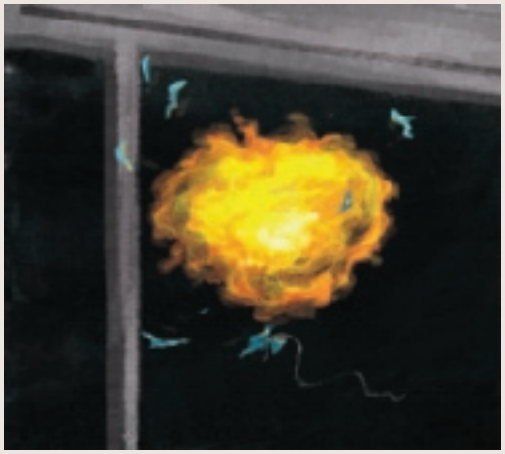
*Artist: Andy Green*

## Flight

Balloons are symbols of joy and delight. The irony behind this beautiful painting is that the balloon is filled with hydrogen, which, when exposed to heat, is highly reactive in the air in which it floats. The thin, colorful walls of the balloon are the only thing standing between the hydrogen gas and the oxygen in the air. Then the balloon is lit with a flame, and it combusts in an exothermic reaction.

*Technique: Acrylic on Canvas*

*Artist: Xia Teng*



## Chain Reaction

Firecrackers are traditionally used around the world in celebration of holidays. This artist is depicting their innocence, as they lie flat and unused. Our eyes are drawn to the lively colors, then we remember the excitement of the flashes and bangs coming from the reaction that will chase the lit fuse from one end of the strand to the other.

*Technique: Metal Print*

*Artist: Al Mlynowski*



## Old and New

Perhaps our exhibit's most renowned piece, "Old and New," depicts the oxidation process of iron containing metal (the old) and the formation of rust (the new). Here, the artist takes a simple reaction that we encounter in our daily lives and turns it into art to show the beauty in everyday exothermic reactions.

*Technique: Mixed Medium*

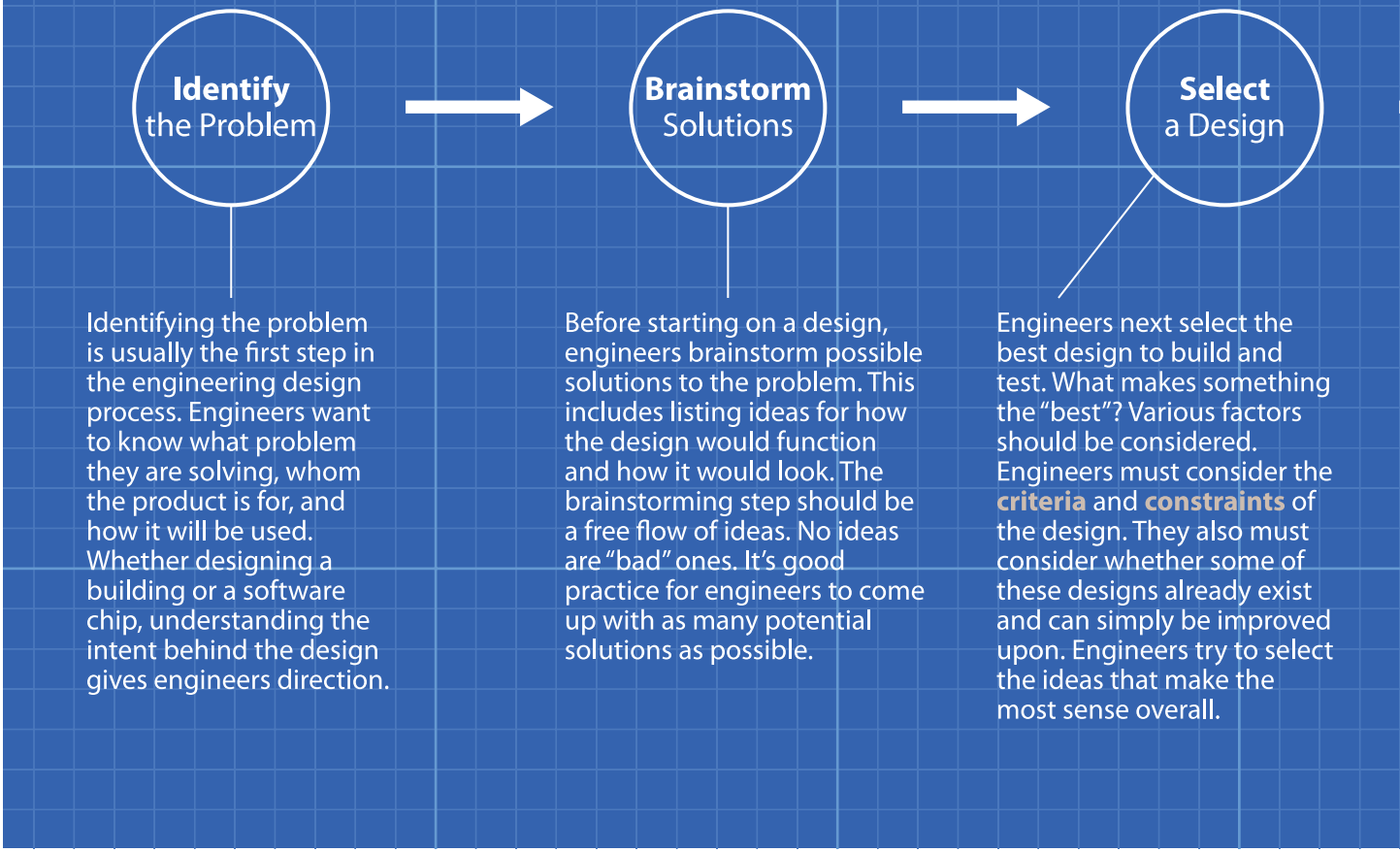
*Artist: Di'angelo M.*



# The Engineering Design Process

Have you ever tried to build a model airplane, bake a cake, or make a fort in your living room, only to have things go horribly wrong? You may have experienced some type of design failure.

There is much to learn from the **engineering design process**. This process encourages people to use problem-solving skills, and it embraces the idea of learning from failure. Engineers follow a systematic series of steps to design, test, improve, and retest their ideas to make solutions to problems. Sometimes designs work, and sometimes they don't. While there are core characteristics of the engineering design process, the process also has flexibility. You can repeat certain steps before a design is finalized, and you can conduct some of the steps out of sequence.



## Vocabulary

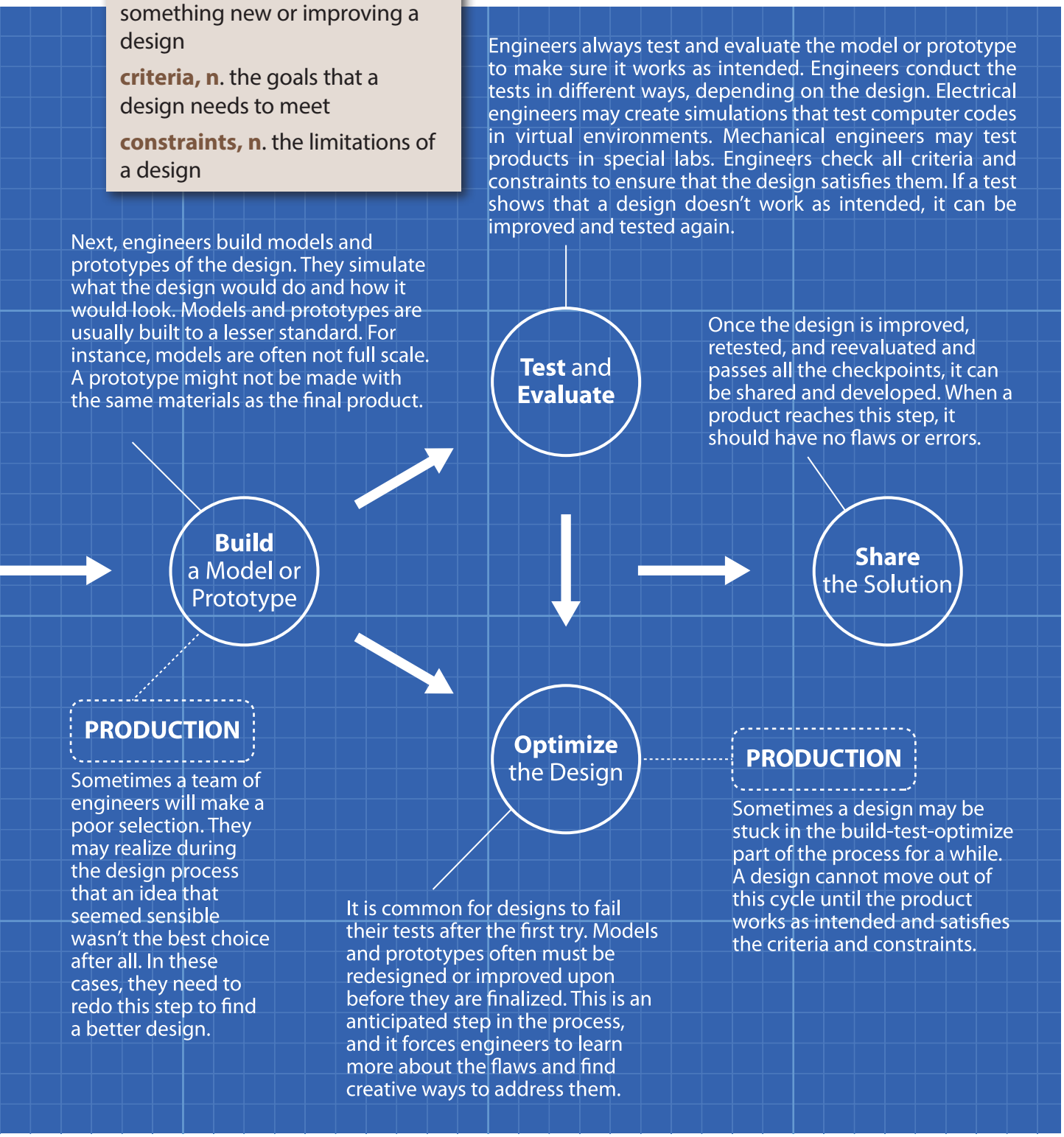
**engineering design process, n.** the steps that engineers go through when designing something new or improving a design

**criteria, n.** the goals that a design needs to meet

**constraints, n.** the limitations of a design

## Word to Know

*Simulate* means to imitate the function or appearance of something else.



# Famous Hollywood Engineers

There is nothing Hollywood loves more than producing action-packed movies that contain innovative and sophisticated technology designed to leave the audience in awe. But even in the movies, designs do not always go according to plan. It's possible you've seen the engineering design process play out on the big screen without even realizing it! Some of the most well-known movie engineers and their designs are described here.

## Tony Stark in *Iron Man*



One of the most popular movie engineers is Tony Stark from *Iron Man* and *The Avengers*. According to Marvel Comics, Stark is an electrical and mechanical engineer. He's a genius and has a double major in physics and engineering.

Soon after we first meet Stark in *Iron Man*, he is kidnapped. He needs to escape, but he has limited tools, resources, and time. He manages to escape by using an "arc reactor" that is implanted in his chest. Once back home, Stark works tirelessly to improve his Iron Man suit design. The audience gets to watch as several of his designs fail comically. Eventually, Stark improves the design enough to share the solution with the world as a comic book hero.

## The Engineers from *Apollo 13*



The blockbuster hit *Apollo 13* is based on true events. In 1970, the astronauts aboard Apollo 13 launched for the moon, but an oxygen tank exploded, and they had to abort the mission. The movie shows how they fought to stay alive in space as carbon dioxide ($CO_2$) levels crept higher and higher.

Meanwhile, NASA engineers on Earth carried out the engineering design process to make a square $CO_2$ filter fit inside a round connector using only tools available on the spacecraft. Throughout the movie, we see the dramatic steps involved in the engineering process, from brainstorming to building and testing prototypes. Time is a major constraint for the engineering team. They must act fast, as the astronauts' lives are in their hands. In *Apollo 13*, the engineers can develop a workable design in just three days to save the astronauts!

## Wayne Szalinski in *Honey, I Shrunk the Kids*



Wayne Szalinski from *Honey, I Shrunk the Kids* is a home-based inventor of interesting gadgets. One day he designs a machine, stored in his attic lab, that accidentally shrinks his and the neighbor's kids. Before realizing what happens, Szalinski breaks his machine after feeling defeated at his career. Talk about a problem! But once Szalinski learns that his machine works, it's up to him to save the kids. Szalinski must rebuild the machine to bring the kids back to normal size. Throughout the movie, we see Szalinksi engaging in parts of the engineering design process by identifying the problem, brainstorming solutions, and building the machine that will restore the kids to their normal sizes. In the end, his solution works, and his shrinking machine is a success!



## "Doc" Brown in *Back to the Future*



Emmett Lathrop "Doc" Brown, PhD, from the *Back to the Future* trilogy is another one of our favorite Hollywood scientists. Doc Brown is a physicist who uses the engineering design process to build the fan-favorite DeLorean time machine. He wants to travel through time, but he needs to power his "flux capacitor" to do so.

In *Back to the Future*, the flux capacitor is originally powered by nuclear material. However, when Marty McFly is sent back in time, the nuclear material is not available to him there. For him to return to the current timeline, Doc Brown has to redesign the time machine so that it works without nuclear material. In the engineering design process, this is both a problem and a new constraint. Doc Brown has the challenge of brainstorming and testing ideas. Eventually, he works out how to make a lightning bolt power the flux capacitor.

### Dig into Data

The DeLorean in *Back to the Future* takes 1.21 gigawatts (GW) to power the flux capacitor and travel through time. There are 1 billion watts in 1 GW. That's a lot of watts! By comparison, it takes about 350–780 watts to power a home refrigerator.

# Funky Failed Prototypes

Designs do not always go according to plan, even when the engineering design process is carefully followed. Designs may start out one way but turn into something else. Here is a list of some famous design failures that turned into useful products.

## WD-40




If you've ever had a creaky door in your home, you may have seen someone put WD-40 on it. WD-40 is a commercial product, a lubricant that helps take away grease and protects against rust. But let's break down the name: *WD* stands for "water displacement"; *40* represents the number of attempts it took to get the formula right!

This means the developers of WD-40 failed at their formula 39 times before they could package it and put it out for commercial use. That's 39 times of going around and around in the engineering design process's build-test-improve cycle!

## Bubble Wrap



It's easy to think that bubble wrap was designed as a common packaging material. However, bubble wrap was originally designed to be a trendy new wallpaper in the 1960s. The trend did not take off, and the wallpaper was a flop.

Later, the engineers of bubble wrap—Marc Chavannes and Al Fielding—tried to market it as housing insulation. But that failed, too. Eventually, IBM discovered that the material could be used to package and protect a computer when it was being transported. From there, bubble wrap became an overnight packaging success.

## Synthetic Dye



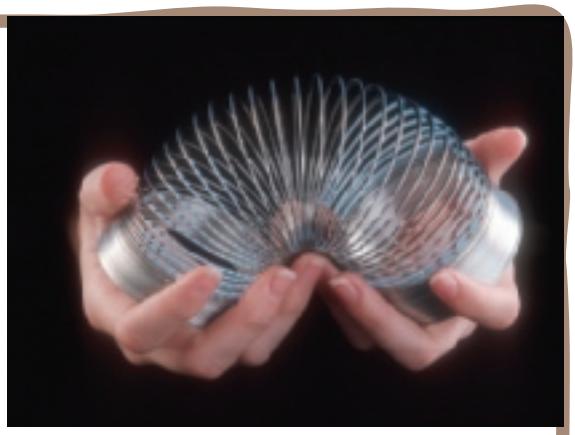
Malaria is a serious disease that makes people very sick with high fever, headache, muscle aches, and exhaustion. In the mid-1800s, chemist William Perkin was trying to create an artificial version of quinine, a drug then used to treat malaria. His experiments failed again and again. They also left behind a sludgy, dark residue. Eventually, Perkin realized that the residue could turn materials a pretty shade of purple. He had accidentally created the first synthetic dye, mauvine. Synthetic dyes are commonly used in the interior design and fashion industries. In fact, you may be wearing a synthetically dyed piece of clothing right now!

## Wheaties



Wheaties, the "breakfast of champions," was the result of a fortunate misstep at the Washburn Crosby Company. While making bran gruel (a type of hot cereal that resembles oatmeal), a worker at the food production factory spilled some gruel onto a nearby stovetop. The gruel crackled and turned into crispy flakes. Curious, the worker tasted it, and everyone agreed that the flakes were better than the gruel. The Washburn Crosby Company decided to scrap their gruel recipe and focus on this tasty flake that could be eaten cold instead of warm. It took the company 36 tries (that's 35 failures!) to develop the perfect flake that tasted great, would hold up in milk, and wouldn't crumble when stored and shipped in cereal boxes. Workers on the product development team must have tasted a lot of wheat flakes during that design process!

## Slinky



A Slinky doesn't look like a traditional toy, and that's because it was originally intended to work as an industrial equipment stabilizer. In 1943, Richard James—a naval engineer—developed springs that kept fragile equipment stable on boats. One day, James accidentally bumped into a spring that was on a shelf. The spring did its famous Slinky walk down the shelf, rather than just falling and hitting the floor. It was James's wife who saw the potential for a toy. Together, they demonstrated the Slinky in front of the famous Gimbels department store in 1945, and it was an instant hit.

## Post-it Notes



The Post-it Note was another prototype flop. In 1968, Spencer Silver, who worked for 3M laboratories, was trying to develop a mega-strength adhesive, but it was never sticky enough to fulfill the criteria. The adhesive worked well enough to stick to objects, but it could be easily lifted off. Silver tried to pitch the design to his company, 3M, but nobody was interested, that is, until a colleague used the sticky note as a bookmark for a hymnbook. It was then that they realized the Post-it Note had potential! In 1980, 3M began selling Post-it Notes to the public, and they have been a success ever since.

# Gathering Feedback

It's very common to buy something and then afterward receive a phone call or an email from the company wanting to know how you like the product or service.

Feedback is important to the engineering design process. Feedback can make improvements, solve problems, or address other concerns. Engineers rely on feedback to know how well their product works. There are different ways to gather feedback, depending on the industry. Some methods focus on the customer or user. Other methods are based on internal testing and peer reviews.







## Satisfaction Surveys

A customer satisfaction survey is among the most popular forms of feedback. A survey is a list of questions that customers answer so an engineer may gather feedback on their product. From there, improvements to products can be made for quality control and to better meet the needs of consumers.

## Customer Ratings

A rating is equivalent to a score. The question "How would you rate this product?" offers quantifiable options that can be measured. Ratings are usually quick and simple means of collecting feedback, requiring the customer to only click a button or a star on a digital device. Engineers use ratings to give themselves an idea of how well their product is working.

## Customer Reviews

Customer reviews are short editorials about how a customer liked, disliked, or experienced a product or service. Some reviews are kept between the customer and the engineers. In these cases, engineers use the feedback to make improvements where necessary. Other reviews are made public for anyone to read. As with a rating, a review can influence whether or not other consumers purchase a product.

## Beta Testing

A more technical and specific process for gathering user feedback is beta testing. Engineers test their nearly finished prototypes on customers before the products have been developed for general use. Participants use a product, such as a home security camera or a toaster, in the real world and describe their experience with it. Their feedback is sent to the engineers and developers to help them adjust their prototypes.

## Internal Testing

Engineering companies have internal labs where designs are tested and evaluated against rigorous criteria. According to the engineering design process, once a prototype is built, it needs to be tested. The people who perform these tests are trained in setting up testing environments and simulations in a lab that will adequately assess a design to see how well it works. Whether an engineer is designing a software code or the seat belt for a vehicle, all designs go through a testing and feedback process.

The results of a test are evaluated and presented to the engineers. A design that passes the tests and receives positive feedback can move forward. If the feedback is poor, engineers move a step back in the design process. Once improvements are made, the design is retested. This process can repeat as many times as needed for the product to work as intended and satisfy all design criteria.

## Peer Reviews

Engineers also gather feedback through a process in which a peer, such as a coworker or other engineer of equal expertise, reviews a design and provides feedback. It is common for engineers to review each other's work, checking to see that a design makes sense, is effective, is resourceful, meets the criteria, and works as intended.

### Word to Know

When something is *quantifiable*, it means it can be counted or measured.

### Connection

We live in a feedback-centric world. Feedback creeps into our daily lives in many ways. For example, the number of followers and likes on a social media account are all forms of feedback. Even comments as simple as "Love it!" or "Same!" are feedback. Where else do you notice feedback in your day-to-day life?

# Engineering in Poetry

Poets have long expressed desire to understand the design of beautiful things and creatures, the architecture of physical spaces, and the meaning of life and love. Here are a few poems that embrace concepts of engineering and design, directly or through symbolism.

## Word to Know

*Symbolism* is a literary method of using words or other means to represent something else, such as an idea or an object.

*Design*
Robert Frost 1874–1963

I found a dimpled spider, fat and white,
On a white heal-all, holding up a moth
Like a white piece of rigid satin cloth—
Assorted characters of death and blight
Mixed ready to begin the morning right,
Like the ingredients of a witches' broth—
A snow-drop spider, a flower like a froth,
And dead wings carried like a paper kite.

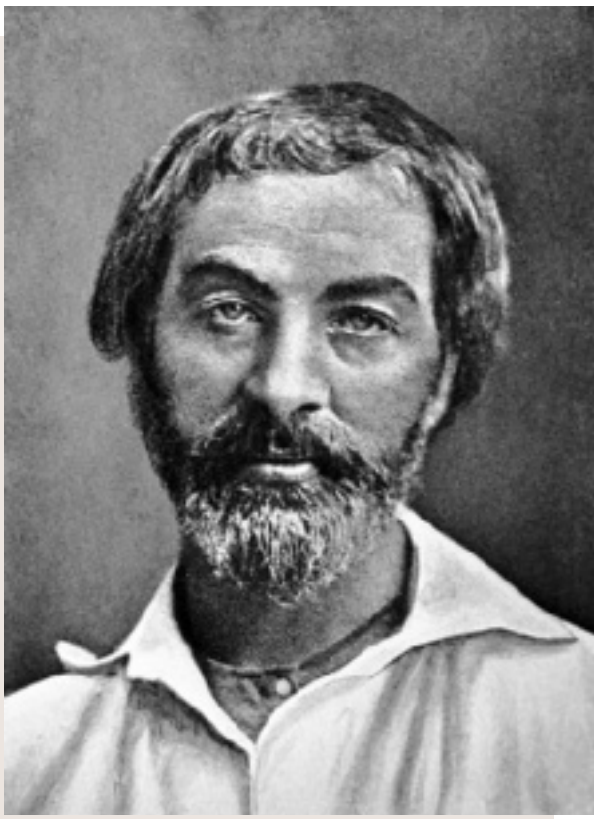
What had that flower to do with being white,
The wayside blue and innocent heal-all?
What brought the kindred spider to that
height,
Then steered the white moth thither in
the night?
What but design of darkness to appall?—
If design govern in a thing so small.





*The Props Assist the House*
Emily Dickinson 1830–1886

The Props assist the House
Until the House is built
And then the Props withdraw
And adequate, erect,
The House support itself
And cease to recollect
The Augur and the Carpenter –
Just such a retrospect
Hath the perfected Life –
A Past of Plank and Nail
And slowness – then the scaffolds drop
Affirming it a Soul –



*Passage to India*
Walt Whitman 1819–1892

1

Singing my days,
Singing the great achievements of the present,
Singing the strong light works of engineers,
Our modern wonders, (the antique ponderous
Seven outvied,)
In the Old World the east the Suez canal,
The New by its mighty railroad spann'd,
The seas inlaid with eloquent gentle wires;
Yet first to sound, and ever sound, the cry with
thee O soul,
The Past! the Past! the Past!

The Past— the dark unfathom'd retrospect!
The teeming gulf—the sleepers and the shadows!
The past—the infinite greatness of the past!
For what is the present after all but a growth out
of the past?
(As a projectile, form'd, impell'd, passing a certain line,
still keeps on,
So the present, utterly form'd, impell'd by the past.)

# Who Are Stakeholders?

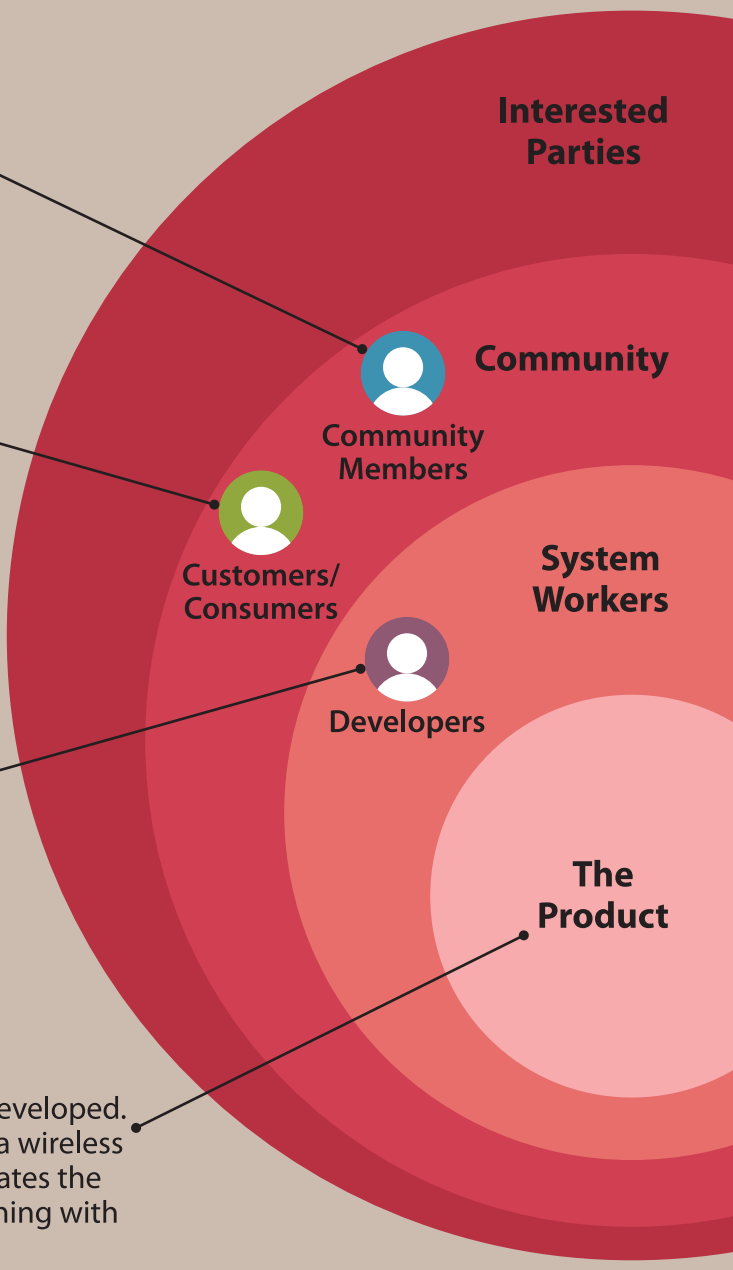
Designers, developers, and engineers must consider the opinions of **stakeholders** of a product when brainstorming the possible solutions to a problem. Some types of stakeholders are more engaged in the engineering design process than others. They help establish the criteria and constraints early in the steps. Other types of stakeholders are far removed from the process but still have an interest in the product later.

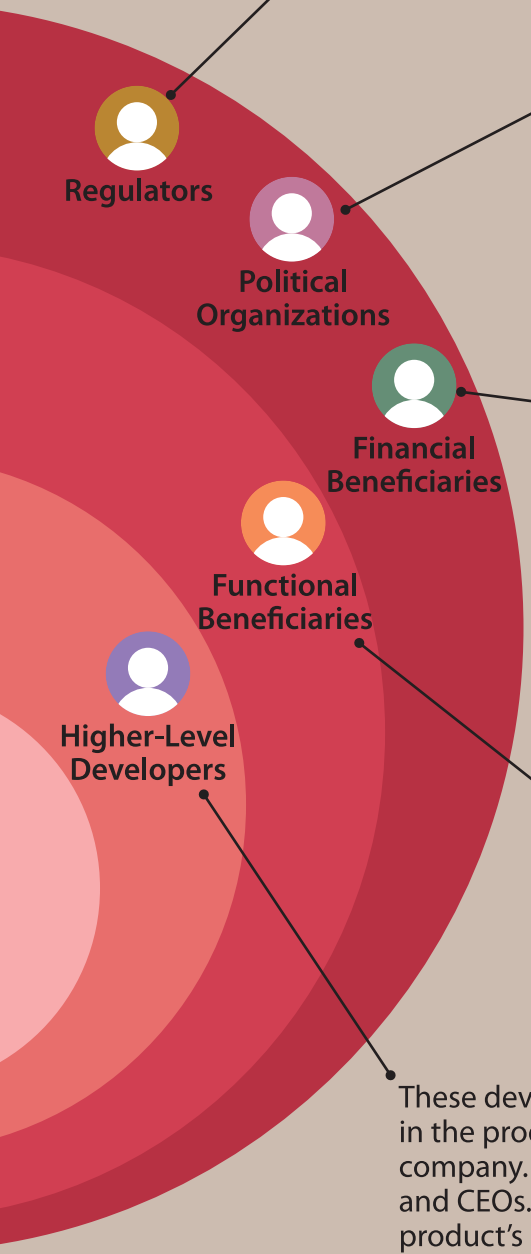
Community members live among the people who use the product. They may (or may not) benefit indirectly from its development. For example, if a company builds a car that runs on green energy and enough consumers in an area purchase these cars, then community members will indirectly benefit because the environment around them will be cleaner.

Customers and consumers buy and use the product. The product is made for them. They ultimately determine the fate of a new product, so their buy-in as stakeholders is very important.

Developers are those who are creating the product. They are usually internal personnel and include engineers, engineering designers, architects, analysts, evaluators, and those who provide operational support, such as IT teams.

The product is the thing being developed. It might be a software program, a wireless router, or a vehicle. This ring initiates the hierarchy of stakeholders, beginning with those closest to the product.






Government agencies, local authorities, and compliance committees may have an interest in the development of a new product, especially to ensure public health, safety, privacy, and protection. Such regulators impose rules and policies regarding how products are to be used, monitored, and maintained for quality. For example, aviation authorities have a stake in the development of products that pertain to air travel and may create requirements for those products.

A political organization may have an interest in a newly developed product if it helps strengthen their political agenda. For example, the distribution of a new software program that improves the accuracy of counting digital ballots may benefit a political organization, thus making the members of that organization stakeholders in the software program.

Financial institutions, insurance companies, and shareholders make money from the distribution of a product, even if they are far removed from its development. For example, banks and insurance companies have an interest in the creation of self-driving vehicles. Why? Customers use banks to take out loans to purchase cars, and banks make money on the interest on those loans. Insurance companies make money by selling insurance for the cars. A shareholder is someone who owns a part of a company. The shareholder makes money when the company's value increases.

Functional beneficiaries benefit from the output of a product. For example, meteorologists benefit from the weather data captured by space telescopes. They do not purchase or use the telescopes, but they gain knowledge from them, which can be useful in their careers.

These developers have a strong interest in the product but rank higher in the company. They might be directors, COOs, and CEOs. They do not interact with the product's development on a day-to-day basis, but they benefit from its success.

## Vocabulary

**stakeholder, n.** an individual who has an interest in something

# Design Test Matrix

Whether you are building a portable air conditioner or a computer program, everything has its own set of standards. These standards often link back to the original criteria of the product. In other words, does the product do what it is supposed to do?

As part of the engineering design process, products are tested once the prototypes are built. People who test the designs keep track of the test results. The information helps developers know if their designs work or need improvements.

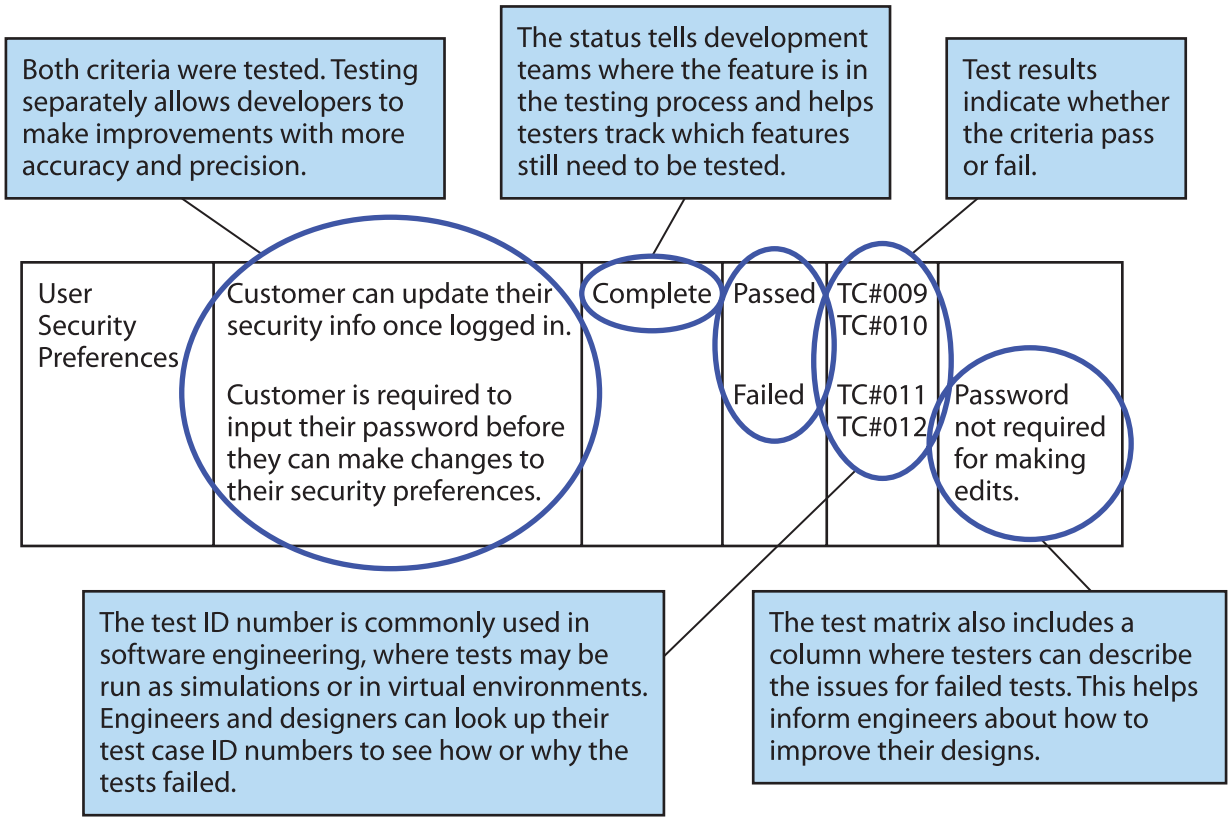
| Feature Name | Requirements | Test Status | Test Result | Test Case ID | Test Notes |
|---|---|---|---|---|---|
| Login | Customer can login to the system on the home page. | In progress | | | |
| Logout | Customer can logout of the system on the home page. | Complete | Failed | TC#001<br>TC#002 | Unable to access home page when logged into system. |
| New User | New users can create new accounts on home page. | Complete | Passed | TC#003<br>TC#004 | |
| Password Help | Customer can request help with password from login page. | Complete | Passed | TC#005<br>TC#006 | |
| Username Help | Customer can request help with username from login page. | Complete | Failed | TC#007<br>TC#008 | Unable to complete test due to system failure. |
| User Profile | Customer can edit profile once logged in. | In progress | | | |
| User Security Preferences | Customer can update their security info once logged in. | Complete | Passed | TC#009<br>TC#010 | |
| | Customer is required to input their password before they can make changes to their security preferences. | Complete | Failed | TC#011<br>TC#012 | Password not required for making edits. |

In engineering, it is common for testers to use a design testing matrix. This visual tool tracks important information, such as design criteria, the status of tests, and other notes. On the previous page is an example of a design test matrix that pertains to the development of a website.

Design test matrices can vary, but they usually have certain basic features in common. Feature names are the parts of the design being tested. Design criteria are described in the requirements column. The criteria/requirements are what the product is being tested for.

Features may have one or more lines of criteria. Below, you can see the feature for User Security Preferences taken from the table.

Some design test matrices may include more columns for retesting features that previously failed their tests. When features are retested, the design test matrix must make it clear that the newer version is being tested. This means a new test case ID number may be assigned, the feature name may be changed, and/or the revised feature may get a new row on the design test matrix.




## Connection

A design test matrix can be created for almost anything you make. If you wanted to perfect the recipe for the ultimate chocolate chip cookie, you could create a design test matrix that lists the different batches of cookies, what was different about each batch, and whether they pass or fail the taste test. You can keep testing and testing your recipes until you arrive at the perfect cookie.

# Science Interviews Podcast

**Pie Competition Episode**

**(Begin transcript)**

**(Intro theme music)**



**Jordan:** Welcome back, friends; I'm Jordan, your science correspondent, and I want to thank you, as always, for listening to my Science Interviews Podcast. I've got a very special guest in the studio for today's episode. I'm pleased to bring you a conversation with one of the world's most famous pastry chefs . . . Patricia Collins, or as she's known in the industry and on TV . . . Chef "Pastry Patricia" Collins. Chef Collins, thanks for joining us on the pod!

**Chef Patricia:** Happy to be here, Jordan!

**Jordan:** I must apologize right off the bat because I'm sure this interview won't be as satisfying as your normal job, where you get to eat delicious pies all day long.

**Chef Patricia:** [laughing] That's true. I rarely work a day when there isn't food for me to taste.

**Jordan:** But trust me, it's a good thing you aren't tasting my cooking, so I'm doing you a favor by not having any food around. [laughing] So let's just jump right into some background about you. I understand that you're a pastry chef who graduated from the French Culinary School and went on to work as an apprentice for some high-level chefs in Europe. You opened your own pastry shop and then wound up as a judge on one of the most popular pastry competition shows on TV.

**Chef Patricia:** You got it! After I opened my pastry shop, there was a series of events that put me in contact with the TV network. They asked if I would do a show with them because they currently did not have any available chefs with my pie specialty.

**Jordan:** So, Chef Collins, as you know, this is a science podcast. And I always try to trace different topics to the science in them. So today I wanted to talk about how you go about selecting the best pie among the competing bakers on your show. I assume you use a strict set of criteria.

**Chef Patricia:** For our baking competition show, all the contestants get a set of criteria. The criteria are the things that the pies need to have. All pies need to have a buttery crust that is flaky but doesn't fall apart when you slice it with a knife. The filling of the pie needs to stay intact and not be too watery. There also needs to be a good proportion between the crust and the filling. Sometimes we add to the criteria to say that all the contestants need to include figs in their pie filling and things like that.

**Jordan:** And you judge the pies according to whether they meet the criteria.

**Chef Patricia:** That's right. The pies not only have to meet the criteria, but they have to also taste delicious! And taste is a little harder to nail down as a criterion because it's so subjective.

**Jordan:** Do you use a checklist to keep track of all these criteria?

**Chef Patricia:** Oh yes. We keep a matrix that lists all the contestants and their pies, as well as all the criteria. And we go through each one, line by line, to see whether the pie satisfies the requirements.

**Jordan:** This sounds like it's a lot more technical than how it appears on the show.

**Chef Patricia:** It's very technical. And contestants also must work within a variety of constraints.

**Jordan:** Such as?

**Chef Patricia:** Well, for one, time is their biggest constraint. They are racing against the clock. They also have limited resources and can only use the tools, equipment, and ingredients that we give them. So they have to get really creative.

**Jordan:** And how do you select the best pie out of all the competition?

**Chef Patricia:** The best pie is the one that meets and exceeds all the criteria and the one in which the quality of the pie is not sacrificed because of the constraints. The best pie also has something that makes it stand out from the rest. This boils down to ingredients and technique. Contestants may be working with the same ingredients, but one contestant may add more of one ingredient or less of another and come up with a brilliant flavor profile or consistency that no one else achieves. This is the sort of thing that sets the winners apart from the rest.

**Jordan:** What happens when things go horribly wrong in a competition?

**Chef Patricia:** Well, if something fails, it can lead to a series of cascading consequences. For example, if someone adds too much liquid into the filling of a pie, the flavor balance will be off, it will make the crust soggy, then the crust will fall apart, and then the filling will spill out of the crust, and you will be left with a messy soup. Trust me: the judges are not pleased when we are presented with pies like this.

**Jordan:** Yikes. Well, here's hoping there are no soggy pies in your near future! Thank you so much for joining us today, Chef Patricia.

**Chef Patricia:** It's my pleasure, Jordan. Thanks for having me!

**(Closing theme music)**

**(End transcript)**

# Toothpaste to Smile About!



Nine out of ten dentists choose Denta-Pro Advanced as their number-one toothpaste and recommend it to their patients.

## *Denta-Pro Advanced*

### Brush Your Way into Freshness

Our customers are smiling and so will you when try Denta-Pro Advanced! Our all-new toothpaste is designed to instantly make your teeth healthier, shinier, and whiter so you can feel confident all day long.

Denta-Pro Advanced toothpaste is better than other so-called leading brands. Denta-Pro Advanced offers dentist-tested and -approved cavity-fighting protection. Thousands of consumers have tested our product, and it is the number-one toothpaste used by celebrities. Our whitening formula is guaranteed to remove unsightly stains to make your teeth up to 50 times brighter! Now THAT'S something you can smile about!



### Spot the BS

Heads up! There's some **b**ad **s**cience on this page. Can you detect which ad is making questionable claims? Which brand of toothpaste seems to have done a more robust job at testing their product?

# A Smile So Bright, It Shines

## DentaDyne Advanced Toothpaste

Try DentaDyne Advanced! And give your teeth the whitening protection they need.

DentaDyne Advanced is designed to make your teeth healthier, stronger, and noticeably whiter after 14 days so you can feel confident in your smile. Our new and improved toothpaste is clinically proven to provide 8 hours of fluoride protection against cavity-causing bacteria.

Unlike other leading brands, DentaDyne Advanced's formula contains vitamin D, which helps prevent dental decay while mineralizing and strengthening teeth. Activated charcoal whitens your teeth while being safe and gentle on sensitive gums. Patients with periodontal disease reported feeling no sensitivity in clinical trials of DentaDyne Advanced.



DentaDyne Advanced is endorsed by the American Dental Association.

### Consider the Source

Both ads feature toothpastes designed to do the same thing. Which ad contains more scientific claims to appear to have more robust testing? What can you infer about the quality of the design process based on the way the ads are written?






# A Survey of Food Poisoning Victims from MREs

by Angela Yakowsky, MD
Medical Director, FresherFoodsForYou

**Introduction** Foodborne illness, also called food poisoning, is a serious and preventable condition that results from eating food that was contaminated by not being prepared or handled properly. Dozens of people recently became sick with foodborne illness after their Meal, Ready-to-Eat (MRE) warming mechanisms failed to heat their food to the appropriate temperature. In response, we conducted a survey of 230 households, all of which purchased MREs within the past 6 months. The survey consisted of 7 questions, and respondents could select from 5 answer choices. Of the households that were sent the survey, 125 responded. The results are shown in the table below.

| Question | Extremely | Very | Somewhat or N/A | Barely | Not at all |
|---|---|---|---|---|---|
| **1.** How satisfied are you with the MRE you purchased? | 17 | 36 | 5 | 13 | 54 |
| **2.** Does the activated food-warming mechanism in the MRE work to your expectations? | 9 | 13 | 10 | 20 | 73 |
| **3.** How much has your digestive health been adversely affected by consuming MRE foods? | 23 | 86 | 7 | 5 | 4 |
| **4.** How disturbed are you by false claims that guarantee air-activated food-warming devices are safe to use? | 91 | 10 | 8 | 2 | 14 |
| **5.** How bothered are you that the MRE did not come with safe-handling instructions, which could have helped avoid foodborne illness? | 88 | 27 | 1 | 7 | 2 |
| **6.** How much has the severity of preexisting digestive ailments such as celiac disease, Crohn's disease, or IBS been increased by the use of MREs? | 38 | 32 | 50 | 2 | 3 |
| **7.** Prior to the use of air-activated warming mechanisms, how concerned were you about getting a foodborne illness? | 11 | 9 | 19 | 64 | 22 |

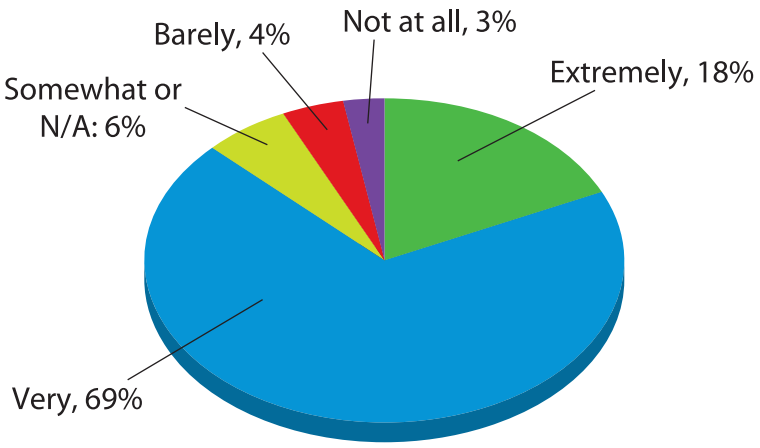
https://FresherFoodsForYou.com

**Conclusions** The results are clear: the food-warming mechanisms for MREs are faulty and cause consumers to have digestive issues and food poisoning. MREs are unsafe to use, and the vast majority of those surveyed responded that their preexisting health issues worsened after eating MREs.

There are too many false claims being made about MREs being safe, which misleads consumers, since most of them were not worried about getting foodborne illness prior to using MREs. Most consumers are bothered by the misguided advertisements that push MRE products on to people without properly informing consumers of how the warming system should work. It's time to keep our consumers safe! Please help in our endeavor to pull MREs from the shelves and replace them with safer and healthier alternatives.

- Angela Yakowsky, MD

**Percentage Adversely Affected by Consuming MRE Food**




**87% of respondents reported having serious digestive problems after consuming MREs.**

## Spot the BS

Heads up! There's some **b**ad **s**cience on this page. Can you detect the problems with this study's design and the author's conclusions?

## Consider the Source

The author of this article is a single person holding a medical degree. While she appears to be the medical director of an organization, the organization's name suggests that she is already invested in an outcome—getting more fresh foods to people—that could be more likely if the findings of her survey cast MREs in a negative light.

## Dig into Data

What is one problem with how the author acquired responses to her survey? How could the data outcomes have been different if the questions were worded differently?

# Glossary

**chemical reaction, n**. a process that involves converting one or more substances (the reactants) into one or more other substances (the products) by rearranging their atoms

**constraints, n**. the limitations of a design

**criteria, n**. the goals that a design needs to meet

**effective, adj**. successful; producing the desired results

**efficient, adj**. achieving maximum effectiveness with minimum waste of effort, resources, and/or expense

**endothermic reaction, n**. a chemical reaction in which energy is absorbed

**engineering design process, n**. the steps that engineers go through when designing something new or improving a design

**exothermic reaction, n**. a chemical reaction in which energy is released

**feedback, n**. returned information that can affect future performance

**flameless heater, n**. self-heating food packaging included with Meals, Ready-to-Eat (MREs)

**optimize, v**. to make the best, most effective, and most efficient use of a design or solution

**product, n**. a substance in the system at the end of a chemical reaction

**quantifiable, adj**. can be counted or measured

**reactant, n**. a substance in the system at the start of a chemical reaction

**reconstitute, v**. to restore food to its original form by adding water to it

**science literacy, n**. the ability to read, hear, and comprehend information about scientific topics and demonstrate understanding in discussion and through writing

**simulate, v**. to imitate the function or appearance of something else

**skepticism, n**. doubt about the proven truthfulness of something

**stakeholder, n**. an individual who has an interest in something

**symbolism, n**. a literary method of using words or other means to represent something else, such as an idea or an object

**test, v**. in engineering and design, to try out a solution to determine how it performs in comparison with expectations (n. a procedure for evaluating performance)

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