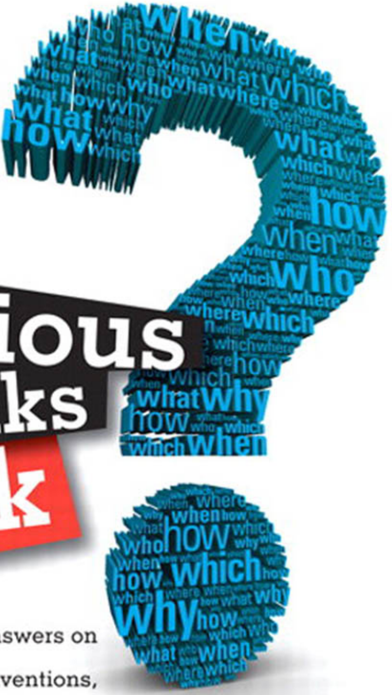

Curious Folks Ask

162 Real Answers on Amazing Inventions, Fascinating Products, and Medical Mysteries

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Preface

Inquiring minds want to know. What's the big deal about low-carb diets? What causes muscle aches when you get the flu? How did the ancient Egyptians build the Giza Pyramids? Does it matter what brand of gasoline you buy? Could adult stem cells have as much promise as embryonic stem cells? Is a horsepower really the power of one horse? Does chocolate cause acne? What makes glue sticky? How is it possible to design bifocal contact lenses? What causes dandruff?

And sometimes, inquiring minds ask questions that other inquiring minds did not even realize they wanted to know. Why do we get skin cancer from sun-damaged skin when damaged cells are continually sloughing off and being replaced? What causes out-of-body experiences? Is the *Star Wars* lightsaber possible? Are there beneficial viruses, just as there are beneficial bacteria? Why do some people have second toes that are longer than their big toes? Is increased environmental noise leading to increased violence? With their unwieldy number system, how did the ancient Romans engineer their magnificent buildings?

These are some of the 162 questions compiled in this science Q&A anthology. The questions come from real people who range in age from high schoolers to octogenarians (and probably even younger and older folks too). Some of them are scientists, and others tell me, "I'm not a science person, but I've always wanted to know..." What they share is a deep curiosity about the world around them. The questions and answers in *Curious Folks Ask* can rekindle the natural wonder about science and the world around us that we all shared as children but that frequently gets pushed aside in formal education settings.

Since I began writing a weekly science Q&A for the *San Diego Union-Tribune* in 2004, not a week has gone by that I haven't learned something surprising from answering readers' questions. People often ask me if I know the answers off the top of my head. Sometimes I do, or think I do, but I extensively research each answer because, after all, science is constantly progressing. There is always something new—perhaps a different way of thinking about things, a controversy where none was evident initially, or a myth that has masqueraded as the truth for so long that many well-informed people have been fooled.

For example, the notion that getting chilled can cause one to catch a cold is dismissed as an old wives' tale by many usually reliable sources. However, a careful search of the peer-reviewed scientific literature turns up a more interesting story, which is revealed in the first Q&A in Chapter 5. This illustrates a unique feature of *Curious Folks Ask*. The concise, palatable answers highlight not just what is known, but also where gaps in scientific understanding exist. Perhaps these mysteries will even inspire a young reader or two to take up the torch and begin a journey into scientific research.

This book is organized into eight chapters of questions and answers about humans and our creations, encompassing a plethora of topics in human biology, rounded out with a touch of chemistry and physics. Individual Q&As are self-contained but are grouped according to the natural themes that arise in people's questions. The questions range from the products of our civilization, to our bodies and how they work, to the nemeses that bring us down, to what makes us tick, to the latest health fads.

- Chapter 1, "Ingenious Inventions." Whether high-tech or seemingly mundane, ancient or futuristic, interesting science is behind every one of our inventions. Folks ponder their origins, how they work, and how to troubleshoot them.
- Chapter 2, "Chemical Concoctions." Chemical-free is the latest silly buzzword being used to market food, personal-care products, and other stuff. Of course, everything, including us, is made of chemicals. Questions about fuel, soap, decaffeination, glue, and more provide insights into the amazing power of chemistry to transform our lives.
- Chapter 3, "Body Parts." Wisdom teeth, appendix, knuckles, and toes—our body parts are mysterious, and sometimes downright odd. How we get our parts, why we have them, and what they do are some of the things people ponder.
- Chapter 4, "Bodily Functions." Itching, yawning, sneezing, sweating—our bodies are rather busy, even when we are doing nothing. Kids, and folks who have grown into perfectly civilized adults, wonder how and why their bodies work as they do.
- Chapter 5, "Pesky Pathogens." Viruses, bacteria, and now prions sure do make it hard to stay healthy. No matter how far medicine advances, they continue to outsmart us. How to keep ahead of

these pesky, and sometimes deadly, pathogens is never far from people's minds.

- Chapter 6, "Assorted Ailments." When we are not under siege by microbes, we still have aches and pains, illnesses, and embarrassing conditions. Young and old alike ask what causes them and why they occur.
- Chapter 7, "Uniquely Human." How we got here, what sets us apart from our fellow creatures, and what makes us feel a certain way may be age-old questions, but modern research is constantly providing a fresh perspective.
- Chapter 8, "Health Nuts." Health advice seems to change every time we pick up a newspaper. From carbs, to free radicals, to gaining the most benefit from exercise, health nuts want the real scoop.

It's all here: the myths, mysteries, oddities, familiar but strange, everyday to exotic. Each answer succinctly synthesizes the current state of a body of research so that you can answer the "whys" of a child in your life, captivate people at cocktail parties, or just satisfy your own inquiring mind.

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Ingenious inventions

Iceless icebox

How does a frost-free freezer work?

In a non-frost-free freezer, water vapor from the air condenses and then freezes on the cooling coils in the freezer (or on the plastic of the freezer compartment covering the coils). If you put off defrosting long enough, eventually so much ice accumulates that there is no longer room for even a TV dinner.

Frost-free freezers prevent this buildup by doing a mini-defrost every six hours or so. A timer turns on a heating coil, which surrounds the cooling coils, and a temperature sensor turns off the heater when the temperature starts rising above freezing.

Full of cold air

How does canned air work? Why is the air cold when it comes out of the can?

The air or gas in the can is under pressure, and it expands as it escapes from the can. Inside the can, where the gas molecules are closer together, there are attractive forces (albeit weak) between the molecules.

Because of these forces, heat energy is needed to separate the molecules. The heat comes from the environment or your skin if it is near the nozzle where the gas escapes.

Most refrigerators and air conditioners work by taking advantage of the cooling effect of an expanding gas (or a liquid expanding into a gas). Refrigerator coils contain a gas that the compressor squeezes into a liquid. Compressing the gas generates heat, which escapes through the coils on the back of the refrigerator.

An expansion valve is then opened between the compressed liquid and the heat-exchange coils inside the refrigerator. The abrupt drop in pressure, akin to releasing the nozzle on canned air, causes the liquid to expand rapidly into a gas. As the expansion occurs, heat from the inside of the refrigerator is transferred to the gas.

Air conditioners are similar to refrigerators, except that air conditioners also have fans to help move the cool air into the inside and dissipate the warm air outside.

May the Force be with you

Is a lightsaber (yes, the Star Wars sword) possible?

Glow-in-the-dark Halloween costume accessories aside, it is not possible to solidify light or make it terminate in midair. However, in his book *Physics of the Impossible*, physicist Michio Kaku explains how to make something akin to a lightsaber. Plasma—an extremely hot ionized gas—could be confined to a hollow rod dotted with small holes that would allow the glowing plasma to escape. Plasma can be hot enough to cut steel. The plasma saber would have to be plugged into a high-energy power supply, though, so it would be more unwieldy than the George Lucas version.

Sci-fi science

A popular weapon in science fiction is a "graser," or gamma-ray laser. Has anyone built one? Does any theory suggest that it is or is not possible? What would be likely uses?

Gamma-ray lasers are technically possible. Lasers that produce emissions in the microwave, infrared, visible, ultraviolet, and even X-ray ranges already exist. The trick to producing gamma rays is finding an adequate lasing medium. This is a substance (gas, liquid, or solid) that gets excited when energy is pumped in. It releases that energy as photons, or particles of light, when it returns to the unexcited state.

In other types of lasers, it is the electrons within the atoms of the lasing medium that get excited to higher energy levels. Whether the photons released are lower-energy microwaves or higher-energy X-rays depends on the size of the energy gap between the electrons' excited and relaxed states.

Gamma rays are too energetic to be produced by electrons jumping from a high to low energy level. Instead, they are produced when an atom's nucleus switches from a high to low energy state. In laser light, photon emission is organized, but getting gamma-ray photons to move in step with each other requires many nuclei to change energy states in unison. This is trickier than getting electrons to change states in unison.

A few elements, including hafnium, have an excited nucleus state that is long-lived, so these elements show promise as a lasing medium for a gamma-ray laser. The U.S. Department of Defense is interested in the problem because a gamma-ray laser would be a formidable weapon.

The laser would also have many nonmilitary applications. For instance, it could be used to probe atoms and molecules to gain an unprecedented understanding of their structure and function, to treat cancerous tumors, or to kick-start nuclear fusion for energy production.

Catching a wave

Why does my radio crackle with static or some other interference? This occurs on AM stations—in particular, more loudly on distant stations and not as badly on some local stations. Is there any way to eliminate this problem?

Many natural sources (static electricity, lightning, solar flares) and man-made sources (motors, electrical equipment) can interfere with radio reception. AM is more susceptible to static than FM because of differences in the characteristics of the transmitted radio signal.

In AM—amplitude modulation—the height of the radio waves, if you visualize them as waves on the ocean, varies according to the signal. In FM—frequency modulation—it is not the height of the waves, but rather the number of waves passing a given point each second, that encodes your favorite music or radio show. Most interference affects the amplitude rather than the frequency of a radio signal.

In addition, radio waves in the frequency range transmitted by AM radio (near 1 megahertz), but not FM (near 100 megahertz), can reflect off the ionosphere, the upper layer of the atmosphere. Since radio waves travel in straight lines, the curvature of the Earth limits their range. Bouncing off the ionosphere and being reflected to Earth allows AM radio waves to travel long distances compared to (ground-based) FM signals. However, interactions with the ionosphere create static, so more distant AM stations have more static than local ones.

You cannot eliminate natural sources of static, but here are some tips for improving radio reception. Turn off any unneeded appliances. Touch lamps or lamps with dimmer switches may need to be unplugged. If practical, try moving your radio to different places in the house (for example, a windowsill) to see where reception is best.

Just turning the radio or moving the power cord can help, because sometimes the AM radio antenna is inside the radio, and sometimes it is in the cord. It is also possible to purchase an external AM loop antenna for some radios. In the case of your car radio, examine the base of the antenna for signs of corrosion.

Out, damned spot!

After I wash my car windows and let them air-dry on a bright, sunny day, I notice a grid of circles about the size of quarters visible on the glass that wasn't there before I washed them. On other cars, the grid is sometimes slightly differently sized and sometimes not perfect circles.

These are mineral deposits, such as calcium and iron, left behind when water evaporates. The pattern depends on how the water evaporates (how well water sheets from your car, the amount of wind, and so on). Also, the concentration of minerals varies in water from different sources.

Vinegar, a weak acid, can help dissolve the minerals and is supposedly the secret of expert car detailers. However, it will remove any wax on your car and cannot fix the paint if the minerals have etched it. Auto aficionados seeking to prevent mineral deposits can purchase a water deionizer that attaches to a garden hose.

Glass stretch marks

I have seen a grid of circles on the factory-provided window tints that also appear to act as the laminate layer. This is especially true on the rear windows of older BMWs after you wash them. It can be seen more prominently with polarized sunglasses. It still looks like a pattern of regular circles about the size of quarters throughout the entire glass.

If (as just discussed) the circles are due to mineral deposits left behind as water evaporates, they should appear on all the windows as well as the paint. Also, they will not form a perfectly regular grid.

On the other hand, if the pattern is very regular, and you see it on only the rear and side windows, the grid is part of the safety glass itself. The rear and side windows are usually made from tempered glass, and the tempering process creates a stress pattern that is visible within the glass.

To temper glass, it is heated to 1,200 degrees F (650 degrees C), and then the outer surface of the glass is cooled rapidly by blowing air over it. The center of the glass cools more gradually. As it cools, it contracts, compressing the outer surfaces of the glass together and creating a stress pattern along the midplane of the glass.

Tempered glass is stronger than regular glass, but when it does break, the internal stress causes the glass to shatter into many small pieces. Since it would be dangerous if a stone shattered the windshield while someone was driving, the windshield is made from laminated safety glass. Some upscale auto manufacturers offer laminated safety glass in side windows for added occupant safety and break-in resistance.

Laminated safety glass consists of two sheets of nontempered glass sandwiched together with a sheet of vinyl in the middle, to which the glass adheres when it breaks. Windows made from laminated safety glass lack the grid of circles characteristic of windows made from tempered glass.

The rear windows of certain cars with window tints definitely have a more noticeable grid pattern. It is possible that the plastic tinted layer has some pattern associated with it, but it is more likely that the tint acts like polarized sunglasses to block some of the scattered light, making it easier to discern the stress pattern in the tempered glass.

Seeing double

Since contact lenses move with your eyes as they move, how are bifocal contact lenses possible?

One bifocal contact lens design—called alternating, or translating, vision—is similar to bifocal glasses. Each lens has two segments. The distance correction is on top, and the near correction is below. The eye moves between the two lens powers as the gaze shifts up and down.

Conversely, simultaneous-vision lenses are designed so that the eyes look through both near and distance powers at once, and the visual system determines which power to use.

Alternating-bifocal contact lenses can be weighted, or slightly flattened at the base, so that the lens is supported by the lower lid and is shifted upward relative to the pupil when the gaze is directed downward.

The simplest form of simultaneous vision is monovision. One eye, usually the dominant one, is fitted with the distance correction, and the other eye is fitted with the near correction. More complicated designs are concentric ring lenses and aspheric lenses. Concentric ring designs feature a bull's-eye pattern of the near and far prescriptions. Aspheric designs have the two powers blended across the lens.

Because simultaneous-vision lenses maintain both the near and far prescription powers in front of the pupil at all times, both powers focus light onto the retina. Therefore, the retina receives two images—one that is in focus and one that is out of focus. Over time, the brain learns to make sense of this strange state of affairs by paying attention to the clear image and ignoring the superimposed out-of-focus image.

The adaptation is not perfect. Monovision reduces depth perception because only one eye receives a clear image of any scene. Simultaneous lenses with more than one power per lens reduce visual acuity—the sharpness of an image—because the out-of-focus image creates a veiling effect on the retina.

Another problem with bifocal contact lenses is that the way lenses fit over an individual's cornea is unique. As a result, it is not easy to predict where the optical center of the lens will be and whether the power zones will line up correctly with the pupil.

Because of these challenges, bifocal contact lenses are not as popular as single-prescription lenses. However, the technology has improved, and there are more designs to choose from. Which design is best for an individual depends on the shape of the eye as well as a person's lifestyle and activities.

Say what?

Why is it so difficult to make a hearing aid that works?

Designing a good hearing aid is actually a difficult engineering problem. When people suffer hearing loss, they often lose the ability to hear some sounds but not others. For example, presbycusis—age-related hearing loss—usually first diminishes the ability to hear higher-pitched sounds.

Therefore, if a hearing aid simply amplified all sounds equally, the sounds that were already audible would become uncomfortably loud. For this reason, hearing aids need to be adjusted to each patient's particular hearing deficits.

Hearing aids also must amplify speech sounds while minimizing background noise. Directional microphones can help, because a listener usually turns to face a person who is speaking, allowing the microphone to pick up the voice but not sounds from other directions. However, random noise can come from the same direction as the speaker's voice, especially if sounds reverberate substantially off surfaces in the room.

Sometimes the solution to one problem leads to another. For example, reducing the size of hearing aids is desirable, not just for comfort and aesthetics, but also to minimize the occlusion effect—that hollow sound of one's own voice when something blocks the ear canals. Unfortunately, shrinking the device places the microphone closer to the hearing aid output and increases feedback. Feedback occurs when some of the amplified sound is fed back to the microphone in a repeating cycle, causing an annoying whistle or squeal.

The technology is improving gradually; the hearing aid industry has been transitioning from analog to digital devices. Digital permits more sophisticated sound processing to enhance speech and reduce feedback and background noise.

On the road again

Assuming all things are equal, does a car get better mileage if the road is wet or dry, the air is very humid or dry, the altitude is high or at sea level, the temperature is very cold or very hot?

According to members of SAE International (the Society of Automotive Engineers), a car gets better mileage:

- When the road is dry. This is because the tires get better traction, and the power is transferred to the road more efficiently.
- In humid conditions. This is because there is less need to throttle the engine. Throttling is a way of controlling the speed of an internal combustion engine, but it consumes some of the engine's power.

  An internal combustion engine is a cylinder in which air and gasoline are mixed, compressed by a piston, and ignited. In the first step of the four-stroke combustion cycle used by most cars, a valve opens to take in air and gasoline as the piston moves downward. Throttling closes the intake valve for part of the time the piston is moving downward, forcing the piston to pull against a partial vacuum, which wastes energy.

  For a particular power output, the engine needs a constant amount of oxygen to burn the required amount of fuel. When more water molecules are in the air, some of the oxygen molecules are displaced. Therefore, in humid conditions, the engine must take in a greater volume of air to get the same amount of oxygen. The intake valve can remain open longer, and less work is required to pump the gases through the engine.
- At high altitude. This is because there is less drag on a vehicle in thinner air. It also takes less effort to expel the exhaust, because the atmospheric pressure "pushing back" on the engine is lower. In addition, less throttling occurs, because a larger volume of air must be taken in to get enough oxygen to burn the same amount of fuel.
- When it is very hot (assuming the air conditioning is off). This is because the air density is lower, so, for the same reason just described, there is less need to throttle the engine.

You may not be able to change where you drive or the weather conditions, but making certain that your tires are properly inflated is an excellent way to improve mileage. Inflating them to more than the manufacturer's recommendation can reduce traction, but inflating too little can reduce the size of your wallet. With too little air, the tires flatten out, resulting in increased rolling friction, which slows down the wheel and decreases gas mileage.

Kooky clocks

As I was engaged in my weekly chore of raising the weights and slightly resetting the time on our 1780s grandfather clock, I wondered how people of that era could accurately set their clocks, which undoubtedly gained or lost at least a minute or two every week. I assume that those with almanacs could try to approximate the time by coordinating with sunrise or sunset, but I don't know if that's true. So how did they set their clocks?

In the late 1700s, the almanac, with its elaborate tables of astronomical and seasonal events, was important in keeping track of time. But back then people still relied on the rising and setting of the sun to mark time. They were much less obsessed than we are now with accurate timekeeping.

In fact, until the late 1800s, cities and towns had independent times, depending on their observation of the sun. Time zones were not considered necessary until trains crisscrossed the country. Pressure from the railroads led the U.S. government to divide the country into four time zones, which were synchronized at noon on November 18, 1883 when the master clock at the U.S. Naval Observatory transmitted the time to major cities via telegraph.

Lost with digital

Why is it possible to point your watch's hour hand toward the sun and then find south between the hour hand and the 12 (assuming you're in the Northern Hemisphere)? How does this relate to sundials?

The sun reaches its high point in the sky at astronomical noon—a moment also known as the meridian. (It comes from the same Latin stem as the terms *ante meridiem*, or a.m., and *post meridiem*, or p.m.) In the Northern Hemisphere, the sun is due south at the meridian because only between the Tropic of Cancer and the Tropic of Capricorn is the sun ever directly overhead.

Therefore, at noon, the shadow cast by a sundial's shadow maker—the gnomon—points directly north. For a sundial to tell time, the noon mark must be oriented to true (celestial, not magnetic) north.

As the Earth rotates, the sun appears to move from east to west around the sky, and the shadow cast by the gnomon moves clockwise 15 degrees per hour (360 degrees in 24 hours).

Think of your watch as a little sundial. If you line up the hour hand with a shadow cast by the sun, you can look to the 12 to find the north/south line. However, because 360 degrees on a watch corresponds to 12 hours rather than 24, the north/south line runs through a point halfway between the hour and the 12. This point faces north between 6 a.m. and 6 p.m., after which it faces south.

Even correcting for daylight saving time, your watch is not a perfect measure of direction, because it is set according to your time zone, but astronomical noon varies across a time zone. Also, because of the Earth's tilt on its axis and its elliptical orbit around the sun, successive astronomical noons are sometimes more and sometimes less than 24 hours apart, causing up to an additional quarter hour difference between watch and sun time.

Era arrangement

The date designations B.C. and A.D. (before Christ and after the death of Christ) seem to leave a gap. In other words, how do we account for the time of Christ's life between these designations? It looks like there is a 30-year life span or so that cannot be included in either the designation "before his life" or "after his death."

A.D. is from Latin, meaning *anno Domini* or "in the year of our Lord." The monk Dionysius Exiguus, who worked out the B.C./A.D. system in the sixth century, assigned A.D. 1 to the year he thought Christ was born. However, most religious scholars place the birth of Christ between 4 and 7 B.C. by comparing what is said in the Bible to known historical and astronomical events.

Let there be light

In 2007, Congress changed the dates on which daylight saving time begins and ends. Have any studies been done to determine if DST has overall economic or societal benefits? I believe it was invented by Benjamin Franklin to aid farmers, but we are far from an agrarian society today.

Benjamin Franklin is often credited with proposing daylight saving time in the *Journal de Paris* in 1784, but his essay was a tongue-in-cheek recommendation that people go to bed earlier and get up earlier. (See http://webexhibits.org/daylightsaving/franklin3.html.)

DST was not adopted until World War I. The rationale was to conserve energy by aligning traditional work hours with daylight hours to reduce the need for artificial light. Farmers, who disliked having to deliver their goods earlier in the day, successfully fought to get DST repealed after WWI. DST was not readopted until WWII.

Between 1945 and 1966, localities could choose when to observe DST. Mass confusion resulted, with radio and TV stations and transportation companies needing to publish new schedules every time a locality began or ended DST. The Uniform Time Act of 1966 addressed this problem by stipulating that any state that chose to observe DST had to begin on the last Sunday of April and end on the last Sunday of October.

Some studies suggest that DST reduces traffic accidents because the evening rush hour occurs during daylight. On the other hand, one study showed that more accidents occur the Monday after we spring forward, probably because commuters are sleep-deprived and/or in a rush.

Proponents of DST cite figures from a 1975 U.S. Department of Transportation study conducted when DST was extended during the oil embargo. The study found that DST reduced the national electricity load by about 1 percent. In 2001, the California Energy Commission estimated that daily electricity consumption would drop by about 0.5 percent if DST were extended through the winter months.

Energy consumption is thought to decrease during DST because people use less electric lighting in the evenings, which is only partly offset by an increase in the use of lights in the morning. People are also drawn outdoors when there is sunlight and therefore use household appliances less frequently.

However, some studies that examined system-wide energy use, including commercial and residential lighting, as well as heating and air conditioning, found no effect or even negative effects of DST, depending on the climate. Also, some studies suggest an overall energy penalty, considering how much the electricity conservation is offset by people taking advantage of the daylight by using more gasoline to go places in the evenings.

Since 2007, DST runs from the second Sunday in March to the first Sunday in November. Because commerce and lifestyles have changed dramatically since many of the studies on the energy-saving potential of DST were conducted, Congress will review the impact of the DST change and reserves the right to revoke it.

Temperature tales

Can you give me a clear and reasonable explanation of the basis of the Fahrenheit scale? We all know that the Celsius or Centigrade scale is based on the freezing and boiling points of water at sea level, but so far nobody has been able to tell me how the Fahrenheit scale was created.

Most historians agree that Daniel Fahrenheit modified a scale developed by the Danish astronomer Ole Rømer. Rømer's scale had fewer subdivisions and placed the freezing point of water at a fractional degree, which Fahrenheit found cumbersome. There are conflicting accounts about how Fahrenheit calibrated his thermometers, but in a paper he wrote in 1724, Fahrenheit described using three fixed points (as translated in *A History of the Thermometer and Its Use in Meteorology*, by W. E. Knowles Middleton, 1966).

To get the 0 on his scale, Fahrenheit said he used a mixture of ice, salt, and water. For his second calibration point, at 32 degrees, he used a mixture of ice and water.

Fahrenheit wrote that the third point was fixed at 96 degrees, where "the spirit expands" when the thermometer is held under the armpit or in the mouth of a healthy person long enough to acquire the heat of the body. (Later Fahrenheit's model thermometers were recalibrated, and normal body temperature ended up at 98.6 degrees.)

Although these are Fahrenheit's words, Middleton points out that they may not be completely accurate because, as an instrument maker, Fahrenheit might have wanted to conceal his methods.

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