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Question From the Classroom

By Bob Becker

Q: We learned in class that all objects have mass—even a helium balloon. So why then does a helium balloon rise?

A: The answer most often given to your question has to do with density. Just as a piece of wood will float upward in a lake because it is less dense than the water, so too will a helium balloon rise in the room because it is less dense than the surrounding air. Although there is certainly truth in that explanation, it really isn't the whole answer. A helium balloon does indeed have mass, and the force of gravity would therefore make it accelerate downward—toward the center of the earth. There must be some greater force acting on it in the opposite direction to make it accelerate upward. And there is; it is known as a buoyant force, and it acts on every object in the room, not just those that are less dense than air.

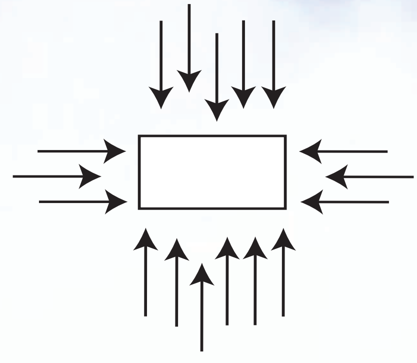
That buoyant force is rather small, only enough to lift about 0.0028 pounds (1.3 g) for every liter of air the object displaces. For most things around us that we might try to lift—a desk, a glass of water, a chemistry textbook, a friend—the buoyant effect is so slight that you would certainly never notice, but it is still there. What this means is that you actually weigh more than you think you do! Let's say you weigh 154 pounds—at least that's what you think you weigh. You would displace about 70 L of air. This translates into a buoyant force upward of about 0.200 pounds* coming from the surrounding air.

70 L × 0.0028 lb/L = 0.196 lb, or 0.200 lb

Take that air away, and you take away the buoyant force. So if you lived in a vacuum (a place with no air or gas of any kind to buoy you up) and you stepped onto a sensitive enough scale, it would show your "true" weight: 154.2 pounds. Hopefully, that would not be cause for alarm—certainly, if you lived in a vacuum, you'd have more to worry about than a little weight gain—but it is something to think about.

But, what if instead of being a 70-L person, you were a 70-L helium balloon!? The helium inside you would weigh about 0.027 pounds and the balloon itself would probably weigh another 0.040 pounds, for a total "true" weight of 0.067 pounds, as measured in a vacuum. Now, factor in the air, and that 0.200-pound buoyant force acting upward on you makes a huge difference. In fact, it would give you a negative apparent weight: –0.133 pounds, which is why you would find yourself accelerating upward toward the ceiling.

But where exactly is this buoyant force coming from? Well, if you have learned about gases, then you are probably familiar with the fact that gas molecules exert pressure in all directions as a result of their continuous bombardment with surrounding surfaces. You are also probably familiar with the fact that the pressure exerted by the atmosphere decreases at higher elevations. The higher up one goes, the thinner (less concentrated) the air is. With fewer molecules colliding, the collective force is weaker. This is certainly true for the air at the top of the mountain—the atmospheric pressure at the top of Mount Everest is about 70% lower than it is at sea level. But it is also true, to a much lesser extent, for the air at the top of a room. This means that there are slightly more air molecules per second hitting the bottom of an object and pushing it upward than there are hitting the top of the object and pushing it downward. There are also molecules hitting the sides of the object, but their forces effectively cancel each other out. This is most easily understood if we simplify the object by making it rectangular as shown in the figure below. The forces acting on the right would be evened out by the forces acting on the left. But this would not be true for the forces acting on the top and bottom; they would add up to a total force upward, and this is what we call the buoyant force.



So how exactly does density enter into the picture? It turns out that the buoyant force acting upward on an object is exactly equal to the weight of the fluid (air, water, whatever!) that is being displaced. This is sometimes referred to as Archimedes' principle. Because a liter of air weighs 0.0028 pounds, a one-liter object displaces that much air and has a buoyant force acting upward on it of 0.0028 pounds. If the object has the same density as air, it would have a true weight of 0.0028 pounds. With the buoyant force factored in, it will have an apparent weight of precisely 0 pounds. That is, it will be neutrally buoyant, neither floating nor sinking. If the object is denser than air, its weight will be greater than the buoyant force; it will, therefore, have a positive apparent weight, and accelerate downward. And if the object is less dense than air, its weight will be lower than the buoyant force; it will therefore have a negative apparent weight and accelerate upward.

Now, here's one more thing to think about: when you make a sharp turn in a car, you and everything else in the car tend to go flying outward. Right? Not necessarily. If one of the objects in the car is a helium balloon, you might be in for a surprise. Check out what it does. But please, make these observations from the passenger seat, not while you're driving! See if you can explain why it behaves that way.

*The metrically minded students out there may be wondering why pounds are being used instead of grams or kilograms. Because this article pertains to forces, the author decided to stick with pounds, which truly are units of force. Grams and kilograms are not units of force. And although 0.200 pounds translates into 90.8 grams, it would be inappropriate to talk about a 90.8-gram force. The correct translation would be into newtons (a 0.89 N force)—the metric unit of force, but for those students who have not yet had a course in physics, a newton would only conjure up images of fig-filled wafers!

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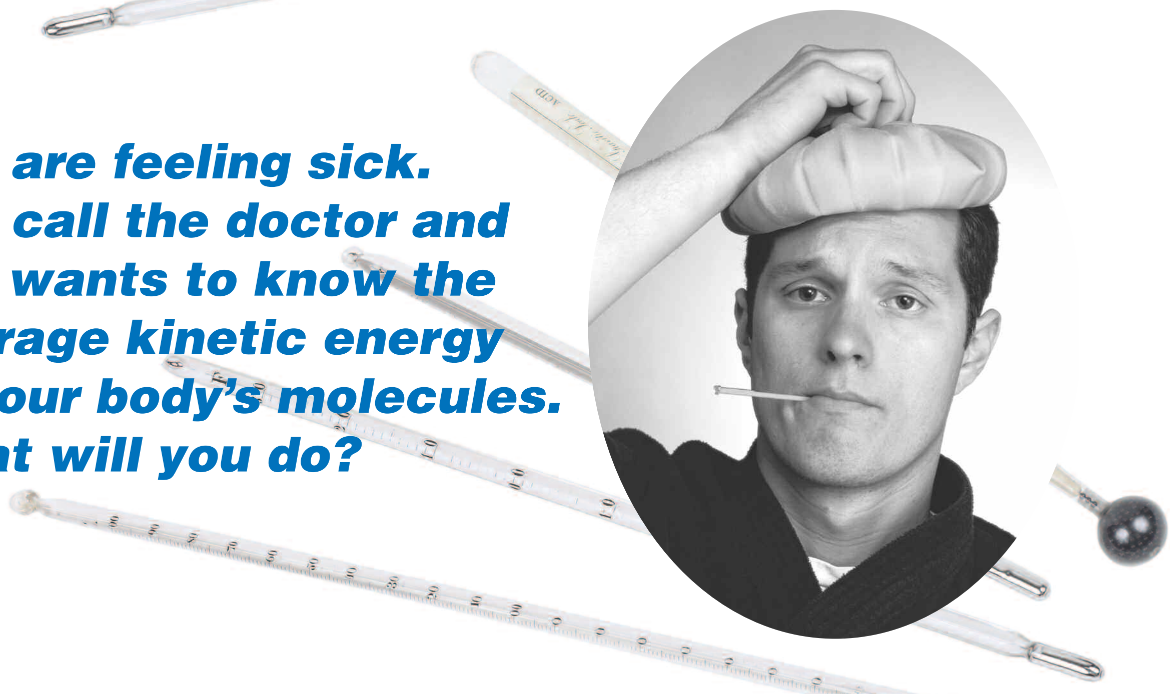
THERMOMETERS



You are feeling sick. You call the doctor and she wants to know the average kinetic energy of your body's molecules. What will you do?

By Brian Rohrig

We have all used a thermometer—to check for a fever, record data during a chemistry lab, or to help us decide how to dress before leaving for school in the morning. But have you ever thought about how a thermometer works? And when you measure temperature, just what exactly are you measuring?

The prefix thermo- refers to heat. Thermodynamics is the study of heat. A thermos either keeps heat in or out. You wear thermal underwear to prevent body heat from escaping. Despite its name, however, a thermometer does not actually record heat, but rather temperature. Temperature and heat are two radically different concepts.

Temperature is a measure of the average kinetic energy of the molecules within a substance. When you record the temperature of something, you are making a statement about how fast the molecules are moving. When you are waiting for a bus in the morning in the middle of January, instead of saying, "Boy, its cold out here this morning," it would be more accurate to say, "Boy, the molecules in the air are moving quite slow this morning!"

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Heat vs. temperature

Heat is a little trickier to define. Heat refers to the movement of energy from a substance of high temperature to one of low temperature. Heat always refers to energy in transit. A substance can have a high temperature, but little heat available to transfer. A drop of boiling water contains less actual heat than a bathtub full of water at a lower temperature. Temperature is a measure of only the average kinetic energy of molecules, but because heat depends on the total energy, there is not a simple, universal relation between the two.

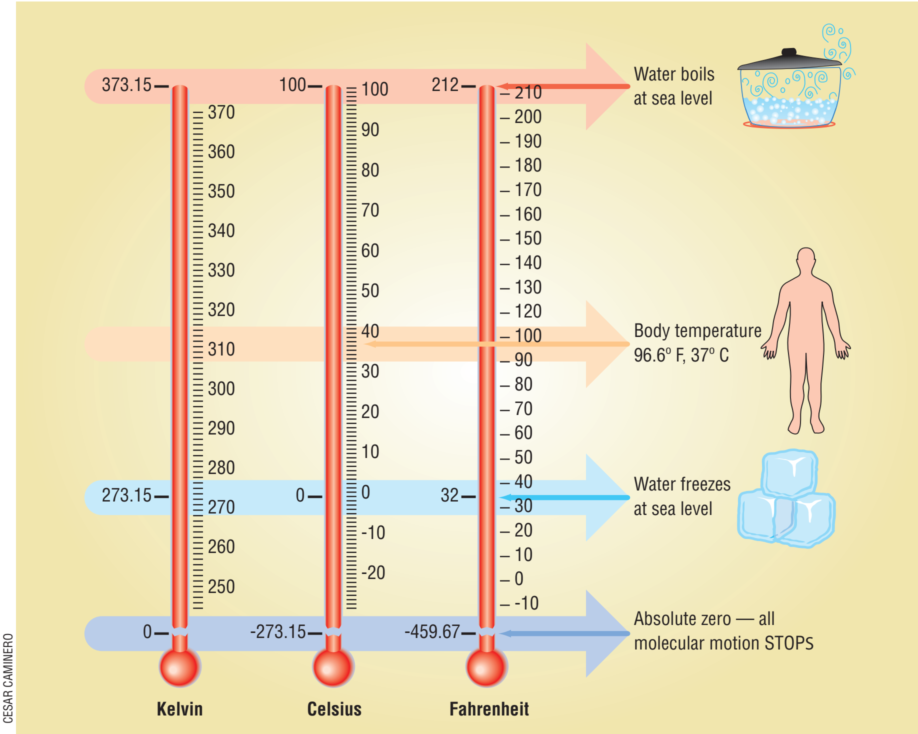
Here's an everyday example that helps to illustrate the difference between heat and temperature. Consider ice: when you cool a drink using ice, a lot of heat flows from the drink into the ice (so the drink's temperature falls). But the temperature of the ice does not rise, it stays at 0 °C—the heat goes into breaking the interactions between water molecules to melt the ice (at 0°) to form water (still at 0°). Ice and water at 0° have the same temperature but very different amounts of heat.

Temperature scales

In the United States, most thermometers for everyday use are calibrated in degrees Fahrenheit. Most of the rest of the world measures temperature in degrees Celsius. At one point during the 18th century, there were nearly 35 different temperature scales in use! Many scientists felt the need to devise a uniform temperature scale that would meet widespread acceptance.

One temperature scale that met with some success was the Romer scale, which was first used in 1701. This temperature scale was invented by Ole Christensen Romer, a Danish astronomer whose biggest claim to fame was measuring the speed of light in 1676. His temperature scale set the boiling point of water at 60° and the freezing point at 7.5°. The lowest temperature you could achieve with a mixture of salt and ice was 0°. Because most people from that time period were not too concerned about the temperature of ice and salt, this scale was destined for the dustbin of history.

Daniel Gabriel Fahrenheit, a German physicist, published an alternate scale in 1724. Borrowing from the work of Romer,



CESAR CAMINERO

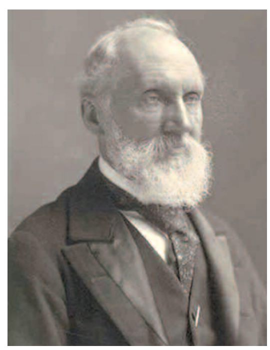
A comparison of three temperature scales.

he set 0 °F as the lowest temperature that could be achieved with a mixture of salt, ice, and ammonium chloride. (It is unclear whether Romer also used ammonium chloride in his experiments, as many of his records were destroyed in a fire.) Fahrenheit set the freezing point of water at 32° and the body temperature of a person at 96°, which he determined by measuring the temperature under his wife's armpit. Each degree of his scale corresponded to one ten-thousandth the initial volume of mercury used in his thermometer. To this day, there is considerable controversy as to how Fahrenheit actually arrived at his temperature scale. He never did reveal exactly how he arrived at the reference points for his thermometer, as he did not want others to construct and sell the thermometers he had spent much of his life perfecting.

His scale met widespread acceptance because everyone could relate to it, since 0 °F and 100 °F were the lowest and highest temperatures typically experienced on any type of regular basis in Western Europe. If the temperature rose above 100°, you knew it was really hot. If the temperature dipped below 0°, you knew it was quite cold. Whether these points were intentionally chosen to represent these extremes or just happened to work out this way is still being debated today. The biggest problem with this scale was the freezing and boiling points of water were set at 32° and 212°, not exactly round numbers. This was an issue not so much with the general public, but rather with scientists, who tend to obsess over such things. However, others have postulated that placing 180 degrees between the freezing and boiling points of water was not arbitrary but quite rational, as this number represents the number of degrees in half a circle.

To counter this problem, Swedish astronomer Anders Celsius came up with another scale in 1742, setting the freezing and boiling points of water at 0° and 100°, with 100 divisions in between. Hence, it was termed the Centigrade scale, since the prefix centi- represents one-hundredth. Celsius had initially set the freezing point of water at 100° and the boiling point at 0°. This was later reversed after his death. Most countries that have adopted the metric system of measurement use this temperature scale, as it is conveniently broken down into units of 10. In 1948, the Centigrade scale was officially designated the Celsius scale, although some people still use the outdated term.

Anders Celsius



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Lord Kelvin

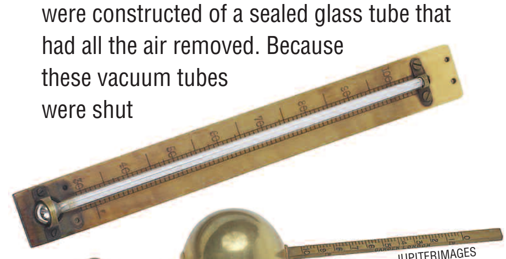
The most scientific scale in use today is the Kelvin, or absolute, temperature scale. It was devised by British scientist William Thomson (Lord Kelvin), in 1848. Because temperature is a measure of molecular motion, it only makes sense that the zero point of your scale should be the point where molecular motion stops. That is exactly what the Kelvin scale accomplishes. 0 Kelvin (K) is the point at which all molecules stop moving. 0 K is known as absolute zero, which has never actually been reached. In 2003 at MIT, scientists came very close to reaching absolute zero, obtaining a frosty temperature of 4.5×10^{-9} K.

The Kelvin scale is primarily used in science, and temperature must be expressed in Kelvin when solving many equations involving temperature, such as the gas laws. But it tends to be too cumbersome for everyday use, since the freezing point of water is 273 K and the boiling point is 373 K.

Types of thermometers

Early thermometers

The first thermometer in modern times was a crude water thermometer believed to have been invented by Galileo Galilei in 1593. In 1611, Sanctorius Sanctorius, a colleague of Galileo's, numerically calibrated the thermometer. Many of these first thermometers used wine, as its alcohol content prevented it from freezing and its red color made it easy to read. However, these first thermometers were very sensitive to air pressure, and functioned as much as a barometer as they did as a thermometer. So eventually, all thermometers were constructed of a sealed glass tube that had all the air removed. Because these vacuum tubes were shut



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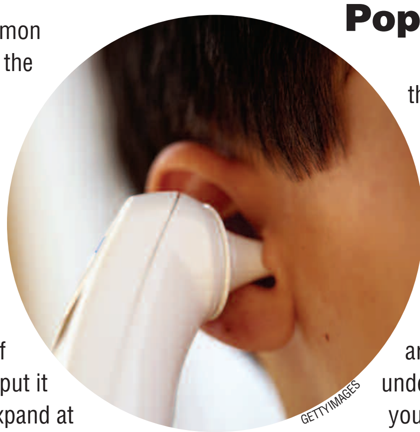
off from the outside atmosphere, changes in air pressure would not affect the temperature reading. In 1709, Fahrenheit invented the alcohol thermometer, and in 1714, he invented the first mercury thermometer. All thermometers work according to the same basic principle: objects expand when heated and contract when cooled.

Bulb thermometers

The most common thermometer is the bulb thermometer, which comprises a large bulb filled with a liquid and a narrow glass tube through which the liquid rises. All liquids expand when heated and contract when cooled (with the exception of H_2O near its freezing point; ice-cold H_2O at 0 °C contracts until 4 °C where it expands like other materials), which explains why the liquid within a thermometer rises as the temperature increases and falls when it decreases. Mercury was the liquid of choice for many years, because it expands and contracts at a very constant rate, making mercury thermometers very accurate. However, because of concerns about mercury toxicity, mercury has often been replaced with alcohol that is colored red. Mercury has a silver color. It freezes at –39 °C, so it cannot be used if temperatures get colder than this.

Bimetallic strip thermometers

Another very common type of thermometer is the bimetallic strip thermometer. This thermometer comprises two different metals, such as copper and iron, which are welded together. Each of the metals used has a different coefficient of linear expansion, or to put it simply, these metals expand at different rates. Connected to this bimetallic strip is a pointer, which points to the correct temperature on the face of the thermometer. Because these metals expand at different rates, when heated, the welded strip of metal will bend. When cooled, it will bend in the opposite direction. A variation of the bimetallic strip thermometer is the thermostat used in homes and automobile engines. These thermostats are made of a thin bimetallic strip, which is fashioned into a coil, making it more sensitive to minor temperature fluctuations.



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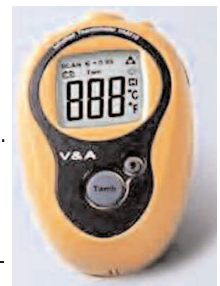
Infrared thermometer

Infrared thermometers

A fascinating thermometer is the infrared thermometer. This handheld device is used by simply pushing a button as you point it toward an object. A digital readout tells you the temperature. All objects above absolute zero are emitting infrared radiation (IR) —an invisible (to human eyes) form of electromagnetic energy. The infrared radiation we emit is commonly known as body heat. The infrared thermometer has a lens that focuses the infrared energy into a detector, which measures the IR intensity and converts that reading to temperature. Infrared thermometers have a wide variety of applications. They are used by firefighters to detect hot spots in buildings and in restaurants to ensure that served food is still warm. Infrared thermometers are also used for determining the temperature of a human body, automobile engines, swimming pools, hot tubs, or whenever a quick surface temperature is needed.



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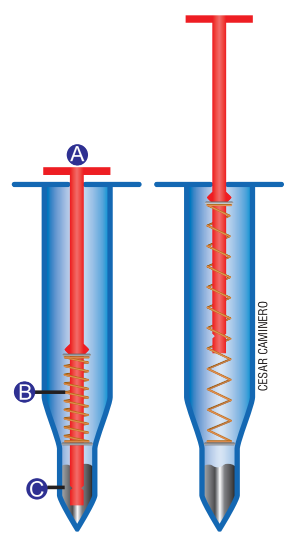
Pop ups

You are cooking that Thanksgiving turkey, and you want to make sure that the inside of the turkey is completely done. To ensure that you are not feasting on undercooked bird, you can use an ingenious device known as the pop-up turkey timer. This instrument is simply stuck into the turkey, and when the turkey is done, a red indicator pops up (A). The little red indicator is spring loaded (B) and is held in place by a blob of solid metal (C). When this metal reaches a temperature of 85 °C, which is the temperature of a fully cooked turkey, it melts, causing the red indicator to pop up.

This technology is similar to that used in sprinklers found on the ceilings of many buildings, which actually served as the inspiration for the pop-up turkey timers. When a certain temperature is reached, a metal component within these sprinklers melts, activating the sprinkler. By mixing together different metals, a particular alloy can be created with a desirable melting point. Pop-up timers can be purchased for a wide variety of different types of meat, from ham to hens. You can even buy a pop-up timer for steak, which pops up in increments indicating rare to well done.



CESAR CAMINERO

Popup turkey timer

And now for something completely different…

Perhaps the most unusual thermometer ever invented is the Galileo thermometer, based on a similar device invented by Galileo. This instrument does not look like a thermometer at all, as it is composed of several glass spheres containing different colored liquids that are suspended in a cylindrical

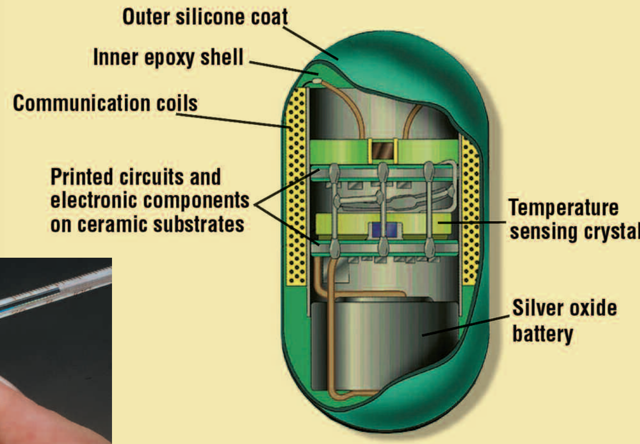
JUPITERIMAGES

Galileo thermometer

column of a clear liquid. Attached to each of the colored spheres is a little dangling metal tag with an engraved temperature. The temperature is determined by reading the tag on the lowest floating sphere. As the temperature rises, the spheres will begin to fall one by one. When the temperature falls, the spheres will then rise one by one.

The liquid within each glass sphere is composed of either colored water or alcohol. Each of the spheres is of a slightly different mass, and thus a slightly different density, since the volume of each sphere is the same. Each sphere differs in mass by about 0.006 grams. This difference is accomplished by making each tag a slightly different mass. The clear liquid surrounding the spheres is an inert hydrocarbon-based oil, similar to mineral oil. When this liquid is heated, it expands, becoming less dense. Less dense liquids exert a lesser buoyant force, so the most dense sphere will then sink. If the temperature continues to rise, the molecules of the surrounding liquid will continue to spread apart from one another, causing more spheres to fall. As the liquid cools, its molecules come closer together, exerting a greater buoyant force, causing the spheres to rise. The spheres themselves do not expand or contract nearly as much as the surrounding liquid when heated or cooled, since they are composed of glass, which hardly expands at all when heated.

Even though it looks nothing like a conventional thermometer, the Galileo thermometer still functions according to the same basic principle as most other thermometers: substances expand when heated and contract when cooled.



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The CorTemp system can measure and record the body temperature and/or heart rate of many athletes on the field during practices or competition. Once the probe is inside the gastrointestinal tract, a crystal sensor vibrates at a frequency relative to the temperature of the body tissues surrounding it. These data are then transmitted harmlessly through the body to the monitor.

What's the future for thermometers?

Technology has come a long way since Galileo's day, but his thermometer to this day has a futuristic look to it. Another futuristic thermometer that is available today is the CorTemp thermometer. Developed by Dr. Leonard Keilson of the Applied Physics Laboratory of the Johns Hopkins University in conjunction with NASA, the CorTemp thermometer is swallowed, allowing accurate temperature readings while it travels through, or is stationed at some particular spot in the body. The probe is enclosed in a small pill that is taken internally, while the temperature readings are recorded on a device that is monitored externally.

No matter what device you use to take your temperature when you have a fever, none will make you feel better. But in this technologically advanced world today, your choice of thermometer might bring you a bit of welcomed distraction while measuring the average kinetic energy of your body's molecules.

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Brian Rohrig teaches at Jonathan Alder High School in Plain City, OH. His most recent *ChemMatters* article, "Glass: More Than Meets the Eye", appeared in the October 2006 issue.

ChemHistory

The Race for Iodine

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By Mark Michalovic

The emperor

Napoleon Bonaparte was known for lots of things. He was a soldier, a general who conquered most of Europe. He was emperor of France. He had a dessert named after him. However, not everyone knows that the little emperor had a thing for science. It may seem odd that even though he was engaged in a war with England, Napoleon would allow the biggest star of British science to visit France to mix and mingle with the top French scientists of the day. Nevertheless, that's just what happened in October 1813. Napoleon granted Sir Humphry Davy permission to spend several weeks in France, even though their two countries were in the middle of a war. There wasn't much Napoleon loved more than war, but it seems even war could take a back seat to his love of science now and then. Little did the emperor realize how much trouble would be stirred up by his graciousness.

The showman

Humphry Davy was born in a far corner of England in a town called Penzance. His family wasn't wealthy, and Davy never had a lot of formal education. He educated himself through his own hard work and became the most important chemist in Britain. A man of many interests, Davy also wrote poetry. Samuel Taylor Coleridge, William Wordsworth, and Lord Byron were his good friends. He loved hunting and fishing as well.

Bonaparte

Davy first made a big splash in science when he discovered the effects of nitrous oxide, or laughing gas, when he was only 21 years old. Later, he discovered two new elements, sodium and potassium, with the help of electricity from a new-fangled battery. He then went on and discovered four more elements: magnesium, calcium, strontium, and barium.

Davy wasn't just a researcher. He was also an entertainer. In those days, lots of people paid money to see science demonstrations. Davy wowed audiences with the wonders of chemistry and electricity. His charm and charisma made him the most famous scientific showman in Britain, and there was nothing Davy loved more than fame.

He didn't mind money, either. In 1813, Davy had plenty of that too, as he married a wealthy widow named Jane Apreece, not long before he left for France. Humphry and Jane would make a sort of honeymoon out of the trip. Not many brides dream of spending their honeymoons in the middle of international scientific spats, but that's what awaited the new Mrs. Davy as the couple headed south across the English Channel.

The protégé

Joseph-Louis Gay-Lussac hailed from a part of central France called Limousin. He was the exact opposite of Humphry Davy in many ways. While Davy had taught himself everything he knew about science, Gay-Lussac had attended the best schools for math and science in France. While Davy was flamboyant and charismatic, Gay-Lussac was calm and reserved. Davy loved leisure, spending lots of time on his many hobbies, while Gay-Lussac seemed to have been wholly devoted to his science. Spending time with his wife Josephine and their children was about his only escape from his work.

Gay-Lussac was patient and careful in the lab. A very by-the-book kind of guy, he was very cautious about drawing any conclusions from his experiments. When he did draw conclusions, he always had lots of experimental results to back them up. This approach paid off when Gay-Lussac discovered Charles' law ($V_1 / T_1 = V_2 / T_2$) and when he discovered that gases always reacted in simple whole number ratios by volume.

Gay-Lussac and Davy were often rivals. After Davy discovered sodium and potassium, the two scientists competed to learn as much as possible about the two new metals. Each often thought the other was horning in on his scientific turf as they raced to make new discoveries. When Davy showed up in Paris in October 1813, perhaps it was only a matter of time before they'd end up competing against each other again.

Gay-Lussac was a friend of an older chemist by the name of Claude-Louis Berthollet. Berthollet had trained Gay-Lussac to work in the lab, and Gay-Lussac was like a son to Berthollet. Berthollet had also brought Gay-Lussac into a circle of scientists who often met at Berthollet's house in the village of Arcueil (pronounced “Ar-koy”), just outside Paris. This group was called the Society of Arcueil, and it included some of France’s leading scientists. Members could use Berthollet’s laboratory and were more likely to get their papers published in the scientific journals Berthollet published. It definitely paid to be a friend of Berthollet.

Berthollet had sent Gay-Lussac on one of his first adventures as a scientist. In 1804, Berthollet asked Gay-Lussac to carry out a very dangerous experiment. Wanting to measure the earth’s magnetic field at high altitudes, he rode a hydrogen balloon to a height of over 23,000 feet above sea level. This set a world record that stood for almost 50 years.

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Davy

Gay-Lussac

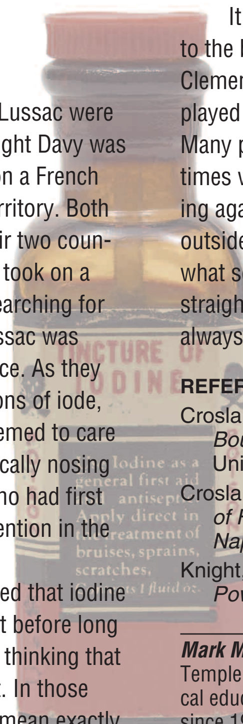
Nine years later, Humphry Davy was making a stir by visiting France during the middle of a war. In November 1813, while Davy was in Paris, Gay-Lussac was given an assignment by the National Institute, France’s leading scientific organization. Two not-so-well-known chemists, Nicolas Clément and Charles Bernard Desormes had reported that a strange new substance had been discovered in seaweed. The substance formed small black crystals and could produce a purple vapor. Even though it was a solid, it seemed similar to chlorine in some ways. Clément and Desormes had carried out some experiments on the new substance and reported them to the Institute. They claimed, among other things, that the substance formed an acid when it came into contact with hydrogen. Gay-Lussac was assigned to review their experiments and repeat them to make sure the results were correct. He set to work, studying the substance carefully and thoroughly. While studying it, he gave the substance a new name. He called it iode, from an ancient Greek word for “purple.” Little did he know that Davy had already been tipped off.

The outsider

Perhaps more brilliant than any of the scientists in the Society of Arcueil was a physicist and mathematician by the name of André-Marie Ampère. He had been a child prodigy and made important discoveries about electricity. He was a scientific genius, but he could be awkward in social situations. He never cozied up with Berthollet and the Society of Arcueil the way Gay-Lussac had.

Maybe if Ampere had been tighter with the Society of Arcueil, they might have told him to be more careful about what he told Davy. At any rate, some time before Clément and Desormes announced their new substance to the National Institute, they gave a sample of the substance to Ampère. Six days before the announcement, Ampère, Clément, and Desormes paid a visit to Humphry Davy. Ampère brought with him a sample of the substance to show the famous visitor. It's at this point that a misunderstanding took place. Ampère probably thought he was showing Davy the new substance as a courtesy to a visitor. On the other hand, Davy claimed the French scientists were asking him to investigate the substance—as if French chemists weren’t smart enough to do that themselves. (Davy was known for his big ego.) Davy had brought a trunk of scientific glassware and instruments with him from Britain. Now, he had a reason to use it and got to work. He began to study the new iode, and gave it it’s English name, iodine.

The race



Once again, Davy and Gay-Lussac were in competition. Gay-Lussac thought Davy was being a bad guest by nosing in on a French discovery right on their home territory. Both probably couldn’t forget that their two countries were at war, and the rivalry took on a nationalistic tone. Davy was researching for King and Country, while Gay-Lussac was researching for the glory of France. As they carried out extensive investigations of iode, neither Davy nor Gay-Lussac seemed to care much that they were both technically nosing in on Clement and Desormes, who had first brought iodine to everyone’s attention in the first place.

Both had originally suspected that iodine was a compound of chlorine. But before long both Davy and Gay-Lussac were thinking that this might just be a new element. In those days, the word “element” didn’t mean exactly the same thing as it does now. Today, we learn in chemistry class that an element is a substance made of only one kind of atom. But in 1813, John Dalton’s atomic theory was only a few years old, and not everyone accepted it yet. Davy especially didn’t like it. Gay-Lussac thought Dalton was onto something but didn’t say so publicly because Berthollet felt otherwise. Even so, chemists still talked about elements. To chemists of those days, an element was a substance that couldn't be broken down into simpler substances. In fact, this definition is just as valid today as it was then. Only now we have a microscopic view (where all atoms are the same) to complement the macroscopic view. Davy and Gay-Lussac both tried to break iodine down, hoping to free the chlorine they thought it contained. Neither succeeded, and both suspected that iodine wasn’t a compound of chlorine, but an element in its own right.

Both Davy and Gay-Lussac published their ideas. Gay-Lussac beat Davy to press by one day, but each always insisted that he’d reached the conclusion first. Either way, Gay-Lussac probably discovered more new knowledge about iodine in the long run. While Davy soon left Paris, traveling with his new bride to Italy, where he studied the chemistry of diamonds, Gay-Lussac kept studying iodine. Gay-Lussac finally published a 155-page paper filled with his experiments and the results. It was considered the best source of information about iodine for many years.

It took several different scientists to get to the bottom of the puzzle of iodine. Courtois, Clement, Desormes, Gay-Lussac, and Davy all played roles. This is how science often works. Many people take part in a discovery, sometimes working together, sometimes competing against each other. Sometimes, the world outside the lab plays a big part in shaping what scientists do. While the path is seldom straight, the road to discovery is almost always an exciting one.

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More on elements

In the *Race for Iodine* you looked back at an age where few elements were known. Today you have at your fingertips all sorts of information on over 100 elements. For an awesome Web site that provides loads of information on the elements, head to: **http://www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=sitetools%5Cperiodic_table.html#**

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As for the He balloon in the car....

As the car turns sharply to the right (for example) and everything in the car leans to the left, the balloon actually accelerates to the right — into the turn! There really is no such thing as centrifugal force. It's more the momentum of the objects in the car and their tendency to continue along a straight line path. As the car turns right, the objects inside tend to go straight, it seems that they are all being pushed outward. All except for the balloon—it seems to get "pushed" inward. But consider the air in the car: it also tends to continue in a straight line and therefore gets crowded to the outside. This creates a pressure gradient sideways inside the car, from a high pressure on the left side where the air is more concentrated to a lower pressure on the right. This is just like the bottom to top pressure gradient caused by gravity in the room. And whereas that gradient gives the balloon an upward acceleration, the sideways gradient in the car pushes the balloon inward (to the right).

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