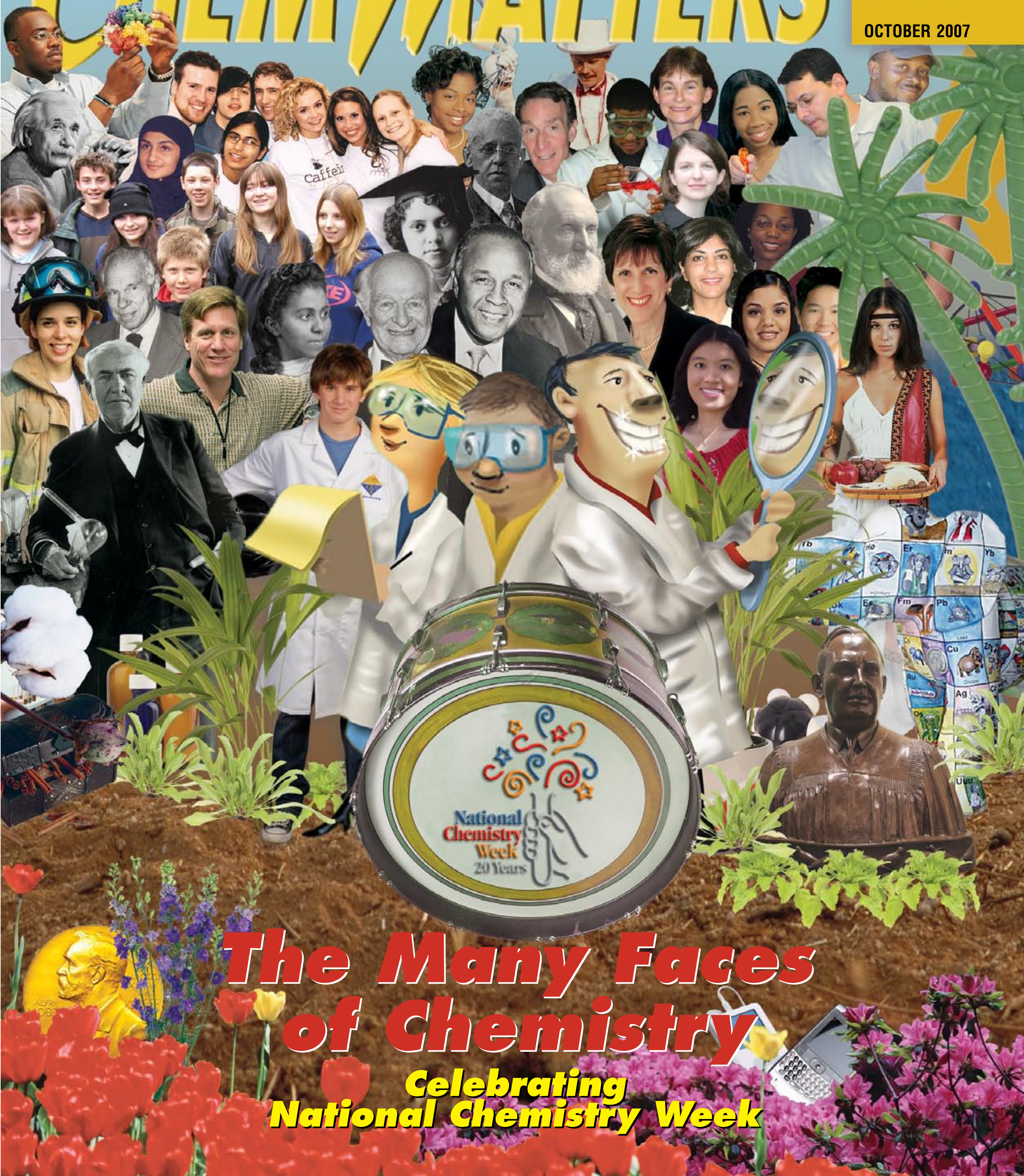
ChemMatters®

DEMYSTIFYING EVERYDAY CHEMISTRY

OCTOBER 2007



The Many Faces of Chemistry

Celebrating National Chemistry Week

CM Demystifying Everyday Chemistry

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QUESTIONS FROM THE CLASSROOM

By Bob Becker

JUPITER IMAGES

Q. Our chemistry teacher told us that science never proves anything. If that is true, why do I always hear about different products that are scientifically proven to work? Besides, if science never proves anything, what good is it?

A. Your teacher is correct. Science never proves anything. Is that a problem? Scientists don't think so. Contrary to popular belief, proving things is not what science is all about. A person who is fed up with his refrigerator because it is unable to *cook* anything just doesn't get what refrigerators are for! Science is for checking out ideas to see whether they work or not. If they do, great! Those ideas can be expanded and improved. And if the ideas don't work, that's great too. They can be replaced with new and better ones.

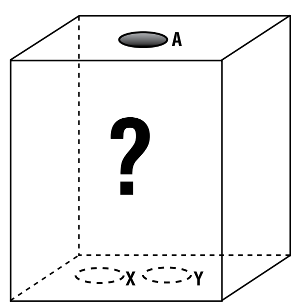
The concept of "proof" is fine for math, but it has no place in science. Scientist Robert K. D. Peterson of Montana State University states: "Many people who do not actively practice science do not understand that science is structured so that scientists can never prove anything."

To illustrate this point, imagine a box with one hole (A) on top and two holes (X and Y) on bottom.

You observe that when you drop a marble into hole A on top, a short while later, it comes out through hole X on the bottom. With nothing else to go on except for this one observation, you imagine in your mind that there is a little tunnel running through the box that leads from A to X. You have just formed a *hypothesis*. You try dropping the marble into hole A again and again, maybe even holding the box at different angles to see what happens. You have just done *research*. You repeat the testing 100 times, and every time the marble is dropped in through A, it comes out at X. You now have it in your mind that there is a tunnel going from A to X. You also figure that it does not connect with hole Y in any way. Now you have developed a theory that has stood up to repeated experimentation. Let's call it the "no Y connection theory."

But can you *prove* the tunnel does not connect to Y? Suppose you drop the marble through a *thousand* times, and every time it comes out at X. Now has the "no Y connection theory" been proven? No! Because marble drop number 1001 could come out at Y.

Indeed, what experiment could possibly be performed to prove absolutely and finally what is going on inside the box? There really isn't one, and that's the point. All we can do is test and revise, test and revise. Cutting the box open to see what's inside may seem like an option. But how do we know that the very act of cutting the box open would not in some way change what the inside of the box looks like?



Is it possible to prove what goes on inside a model box?

Not only can scientists not prove things with absolute sureness, they cannot even measure things without some level of uncertainty! That is because the very act of investigating or measuring a thing changes that thing. Say you are given a small beaker of warm liquid and asked to determine its precise temperature. Easy, right? Just use a thermometer. But the instant you stick a room-temperature thermometer into the warm liquid, you have changed the liquid's original temperature a tiny bit.

So let's go back to the box. Maybe we cannot prove that the tunnel has no connec-

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tion to hole Y, but at least we know there is some kind of tunnel going from A to X. Or do we? Maybe the marble dropped in at A falls into a compartment, triggers a switch inside the box, and causes an identical marble to be dropped out at X from a completely separate compartment. Far-fetched? Sure. Impossible? No. Scientists favor a principle called "Occam's Razor," which says basically: When in doubt, go with the simplest explanation. But they also know that there is no way to prove that the simplest explanation is true.

So if science doesn't prove things, what does science do? Science, at its best, works at getting a progressively better and better picture of what is real and true in the world around us. Paul Grobstein of Bryn Mawr College says that "science is actually a process not of getting it *right* but rather one of perpetually getting it less *wrong*.

This year, your chemistry course will introduce you to protons and neutrons, covalent bonding, and electronegativity. And what all of that amounts to is just this: The current *least-wrong* picture of what matter is all about. But just know that at any moment, with new discoveries, the picture might shift a little—maybe even a lot! We should always be aware that our current understandings may have to be modified based on further insights or experiments. That's what makes it exciting: science is a risky process, not a comfortable end result!

As for the high-priced shampoo that claims to be "scientifically proven" to clean hair better—ignore the hype. You may never see a product ad with this phrase: "Effectiveness is supported by scientific research, not proven." But if you do, buy it!

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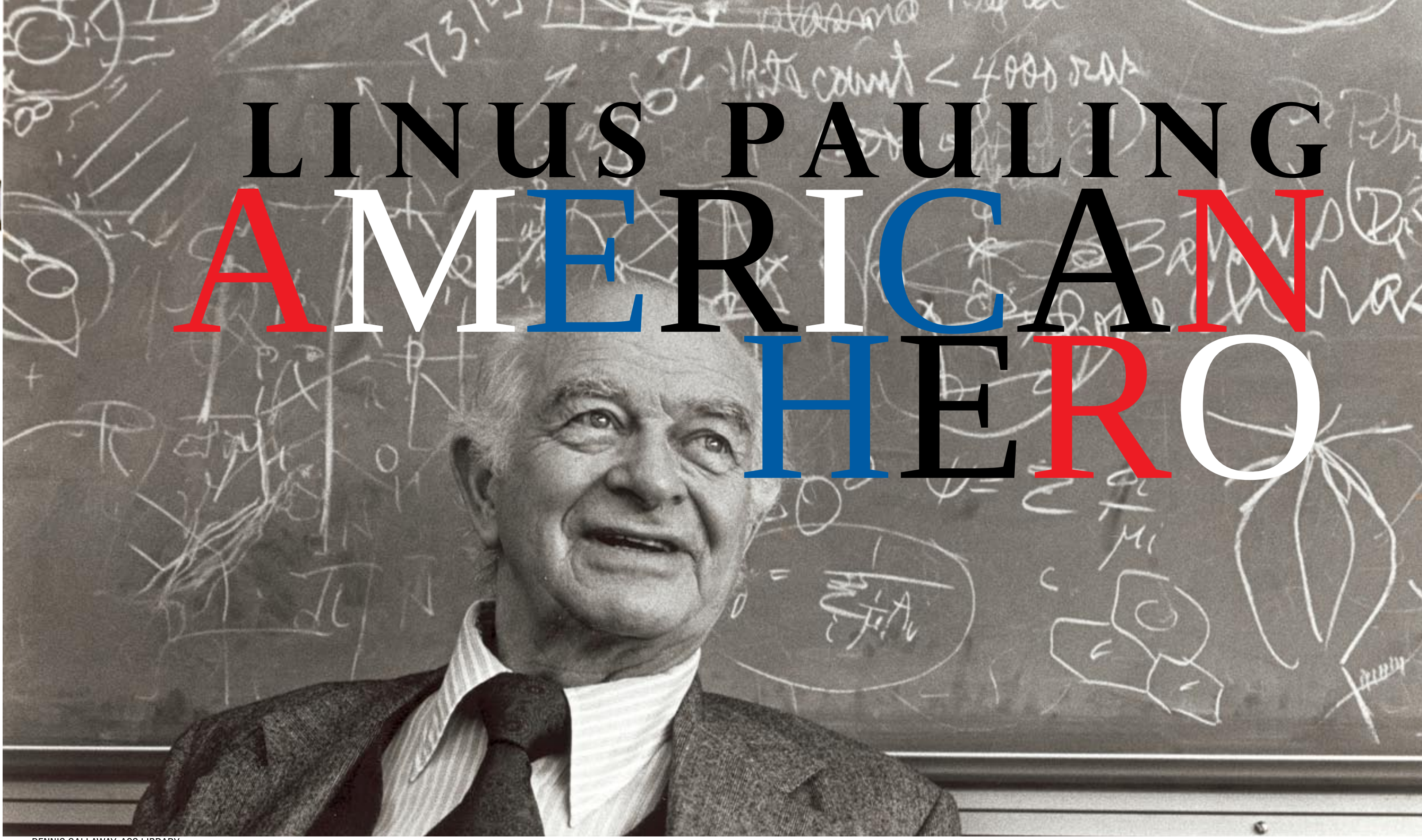
National Chemistry Week 20 Years

LINUS PAULING AMERICAN HERO



DENNIS GALLAWAY, ACS LIBRARY

Talk to career chemists about how they got interested in the field, and chances are you'll hear something like this: ***"My friends and I had this chemistry set. We set up a lab in the basement with equipment we made or scavenged. There were a couple of explosions … minor of course … got in trouble with our parents …."***

And on the stories go. Linus Pauling would tell us just such a story. That's THE Linus Pauling who won two Nobel Prizes, one for chemistry and one for peace.

★ ★ ★

By Sarah Vos

When Linus Pauling was 13, his best friend had a toy chemistry set. Pauling recalled watching a simple manipulation that involved boiling water over an alcohol lamp—and Pauling went home to read about it. Soon, he had his own chemistry lab in the basement of his mother's boarding house in Portland, OR. He scavenged equipment and chemicals from pharmacist friends of his father and from an old iron smelter lab. By one account, he and his friend Lloyd Jeffress soon learned how to combine chemicals to make small explosions; once they set off a loud one off under a trolley, scaring neighbors.

Early years

Pauling was born in 1901. His father, a self-taught pharmacist, died when Pauling was 9. His mother ran a boarding house to support herself and her three children. Money was short, and Pauling worked odd jobs to help out.

By the time Pauling took his first chemistry class at Portland's Washington High

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College Costs in 1920

According to the 1919/20 Oregon Agricultural College catalog, tuition was free to all students, regardless of place of residence.

Regular college fees were as follows:

Entrance fee, payable on registration ***$5 annually***
Incidental student fee ***$3.35 per term***
Gymnasium fee ***$1 per term***
Diploma fee on graduation ***$5***
Binding fee for graduation thesis ***$1***
Vocational certificate fee ***$1***

There were also lab fees and deposits charged on a per-term basis for science and other classes that included a lab component.

Dormitory room rent per term ***$18 single*** ***$9 double***
Board ***$4.50 per week***
Incidentals (laundry, etc.) ***$2 per term.***

School, he had already absorbed the basic rules that govern chemistry. His home laboratory experiences and the information he gathered from studying his father's books impressed his teacher. By the time he was ready to graduate, he knew he wanted to be a chemical engineer.

High school graduation had to wait—and wait! Because of a technicality, Pauling did not receive his high school diploma until 1962, long after he had received his bachelor's degree, doctorate degree, many honorary degrees from around the globe, and a Nobel Prize. Whoever said that high school graduation requirements are easy?

Despite his impressive record in chemistry, college was not an automatic option for Pauling. In the early 1920s, most boys went to work after high school to help support their families. Pauling's mother was barely surviving on the money she earned from the boarding house and her son's contributions from odd jobs. When Pauling got an offer of a good-paying job at a machine shop, his mother urged him to take it. In the end, he chose to enroll at Oregon Agricultural College (now Oregon State University) in Corvallis.

Pauling impressed the professors with his knowledge of chemistry, and, by his junior year, he was teaching a class on general chemical principles and laboratory techniques. The paid position allowed Pauling to stay in school and to send money to his mother.

After graduating from college, Pauling went to the California Institute of Technology (Caltech), to earn a Ph.D. in chemistry. That's where he started studying chemical bonds—the research focus for which he is best known.

Nature of the chemical bond

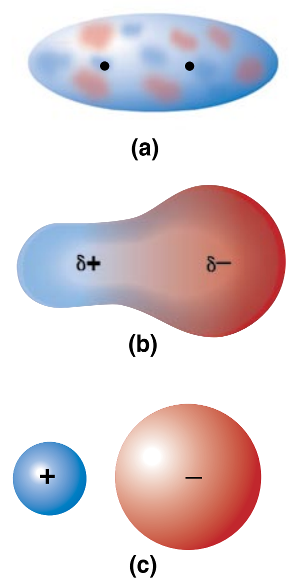
In college, Pauling learned and taught the most current and widely accepted model of chemical bonding—*the hook and eye model*—a name borrowed from the clothing fasteners used at the time. This model proposed that chemical bonds form when the *hook* of one atom connects with the *eye* of another atom. Different atoms had different numbers of hooks and eyes, thus dictating the number of bonds that an atom could form.

For Pauling, the hook and eye model raised more questions than it answered. Why do some atoms like carbon tend to form up to four bonds with other atoms, while other atoms like hydrogen form just one bond? What holds the bonded atoms together? Do the properties of bonds differ on the basis of the elements involved? How does bonding influence structure?

Pauling continued to seek answers to these questions as a graduate student at Caltech, as a Guggenheim Fellow in Europe, and, later, upon returning to Caltech as a professor.

All the while he looked for answers, Pauling made one significant contribution after another to scientists' understanding of the nature of the chemical bond.

As Pauling looked for his answers, many scientists still viewed chemical bonding based on two extreme definitions: one for covalent bonding and the other for ionic bonding. According to Pauling's contemporary Gilbert N. Lewis, a covalent bond resulted from the sharing of a pair of electrons equally. In an ionic bond, one atom "pulls" so strongly on the electrons that it removes the electrons completely, result-



(a) Covalent bonds result from the sharing of a pair of electrons by two atoms.
(b) Polar covalent bonds (bonds with some ionic character) result from the uneven sharing of electrons by two atoms.
(c) Ionic bonds result from one atom so strongly attracting the electrons of another that it removes those electrons, resulting in a negatively charged atom (anion) and a positively charged atom (cation).

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Fellow chemist Choh Hao Li with Linus Pauling.

ing in a negative charge on one atom and a positive charge on the other. The attraction of the negatively charged atom (the anion) for the positively charged atom (called a cation) forms the basis of the ionic bond.

However, Pauling and some of his contemporaries, including Lewis, questioned whether these extreme definitions were accurate or whether bonding could be viewed on a scale or *continuum*. At one end of the continuum would be covalent bonding and, at the other end, ionic bonding. They wondered whether bonds might be described somewhere in between the two extremes, with properties of both kinds of bonding. On the basis of experimental data, Pauling confirmed that bonds could be ionic, covalent, and, for those in between, exhibit a degree of ionic character. He theorized that the major determining factor was how strongly the atoms in the bond attracted the electrons. Pauling called this factor ***electronegativity***—the tendency of an atom to attract electrons in a bond.

Pauling assigned electronegativity values to elements based on their attraction for electrons in a bond. Fluorine, with one of the strongest tendencies to attract electrons, was assigned an electronegativity value of 4; sodium, with a very low tendency to attract electrons in a bond, was assigned an electronegativity value of 0.9. The magnitude of the difference in electronegativity values between two elements could then be used to determine the ionic and/or covalent nature of the bond.

Known today as the Pauling Electronegativity Scale, this scale of electronegativity values is used by chemists all over the world to predict the nature of bonds between atoms, especially when experimental evidence is not available.

As new knowledge and technology became available, such as new theories in quantum mechanics and X-ray crystallography, Pauling continued to fine-tune his explanations for molecular and crystal structure. Pauling developed a set of rules that bear his name to help scientists map the structures of ionic and covalent crystals. In 1939, Pauling put his ideas together in a work called *The Nature of the Chemical Bond*. The book is widely considered to be one of the most influential chemistry works ever written.

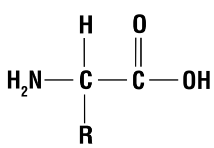
Proteins

Pauling turned his attention to proteins in the mid-1930s. Proteins, found in all living things, are large molecules. Proteins are actually chains of amino acids, small organic molecules consisting of an amino group ($-NH_2$), a carboxyl group ($-COO$), and a variable side group (commonly represented as *R)*.

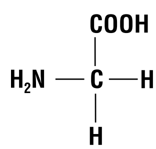
Using the same methods, he brought to study chemical bonds—diagrams, X-ray crystallography, and his set of rules for describing bonds—Pauling unraveled the basic structure of proteins. His work helped establish the field of molecular biology.

Pauling started by looking at the denaturation of proteins. Denaturation is the change of a protein's shape caused by factors such as heat, changes in pH, or high concentration of salts. Boil an egg, and you'll see denaturation at work. The liquid albumen or egg white protein readily solidifies upon heating. The result of denaturation may be a change in the properties of the protein. In some cases, denaturation is reversible; in other cases, it isn't.

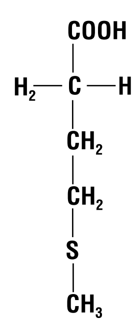
Pauling's study of factors influencing the denaturation of proteins led to an increased understanding of the different types of weak interactions that give proteins their shapes.



Monomer amino acid

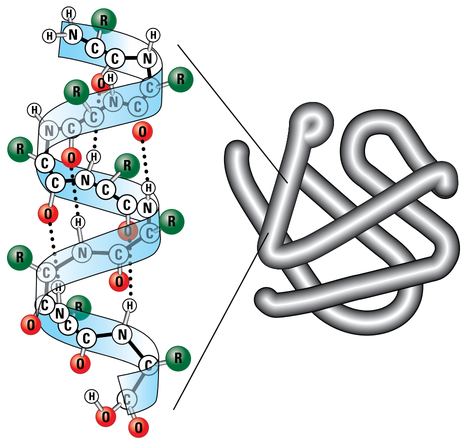


Glycine



Methionine

Amino acids are the building blocks of proteins. All amino acids have the same basic structure indicated by the generic amino acid at left. They differ based on "R" which can be very simple as in glycine (where R is a H atom) or more complex as in methionine (where R is $CH_2CH_2SCH_3$).



Linus Pauling is well known for his work with proteins. The alpha helix, at left, is one of the most fundamental structures of proteins. It is formed through a number of weak interactions between groups at different places along the protein chain. The folded structure is shown at right.

His work with protein chemistry soon led to his discovery and explanation of one of the fundamental structures of protein molecules—the alpha helix. The alpha helix resembles a spring. It is formed when the N-H group of one amino acid is weakly attracted to a C=O group of an amino acid several units down the chain. This type of weak interaction

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Linus Pauling recieves Priestly Medal from Warren Niederhauser.

is called hydrogen bonding. The helix shape allows many of these types of weak bonds to form, thus twisting the protein chain into a spiral.

Pauling's research interests also included the study of hemoglobin, a protein found in red blood cells essential for the transport of oxygen throughout the human body. Hemoglobin exhibits abnormal properties in people suffering from sickle cell anemia, a genetic blood disorder. Pauling demonstrated that the hemoglobin molecule changes shape when it gains or loses an oxygen atom. Pauling, along


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Linus Pauling receives the National Medal of Science from President Gerald Ford in 1975.

with, Harvey Itano, S. J. Singer, and Ibert Wells, discovered that the abnormal shape change that occurs in people with sickle cell anemia was due to a mutation in their DNA. This was the first demonstration that a change in a specific protein was associated with a human disease, thus foreshadowing a revolution in molecular genetics.

Pauling became interested in the effectiveness of vitamin C and other nutrients in treating and preventing a variety of illnesses. He worked, not entirely successfully, to convince the medical establishment of the benefits of certain vitamins, especially C, as dietary supplements.

Pauling received the Nobel Prize in Chemistry in 1954 from the Royal Swedish Academy of Sciences. This prize acknowledged and honored his work on the nature of the chemical bond and his application of this knowledge to understanding the chemistry of macromolecules such as proteins.

Pauling for peace

Working against the backdrop of World War II, Pauling was in favor of United States going to war against the Axis forces of Germany, Japan, and Italy. He contributed his scientific expertise to the National Defense Research Commission and the Research Board for National Security. But when he was invited to participate in the Manhattan Project, in which scientists developed the atomic bomb, he declined—not over any objections to the technology, but because he didn't want to move his family. But when the United States dropped two atomic bombs on Japan, Pauling began to question the use of atomic weapons.

Pauling challenged the U.S. government, arguing that the health consequences of radioactive fallout from the atomic bomb were far greater than the government acknowledged. Although the government argued that the increase of background radiation from nuclear bombs had only a small chance of affecting an individual, Pauling looked at the effect on the entire population. If, he argued, 1.5 million birth defects were caused each year by background radiation, a 1% increase would mean 15,000 more babies born with birth defects every year.

Pauling made speeches, participated in demonstrations, and wrote a book called, *No More War!* Unfortunately, his antiwar protests at this time in history made Pauling the subject of intense scrutiny. Pauling's anti-war activity coincided with the Cold War,

When he and his wife were invited to dinner at the White House with then President John F. Kennedy, Pauling spent the day before the dinner protesting outside the White House. He held a sign that said, "Mr. Kennedy … We have no right to test."

a time when fear of the Soviet Union was at its peak, and individuals who spoke out against the U.S. government and its actions were often considered to be anti-American. The FBI investigated Pauling to see whether he was a member of the Communist Party (he wasn't). His requests for a passport were repeatedly denied, so he couldn't travel abroad. By losing his security clearance, he lost research grants for his work. A pharmaceutical company for whom he did consulting work even fired him.

But Pauling didn't stop. In 1957, working with his wife from their kitchen table, he started a petition to stop the testing of nuclear bombs. Eleven thousand scientists from around the world signed it, and Pauling presented it to the United Nations. The petition helped change public opinion. When he and his wife were invited to dinner at the White House with then President John F. Kennedy—because he had won the Nobel Prize for Chemistry—Pauling spent the day before the dinner protesting outside the White House. He held a sign that said, "Mr. Kennedy …We have no **right** to test."

In 1963, the United States and the Soviet Union signed the first test ban treaty. That same year, Pauling was awarded the Nobel Prize for Peace.

Post-Nobel Prize

Following his acceptance of the Nobel Prize for Peace, Pauling worked for a number of organizations in California, continuing to pursue his passion for understanding the nature of genetic disease. He started his own research institute in 1973, currently called the Linus Pauling Institute (located on the campus of Oregon State University), where he continued to search for ways to understand and treat molecular disease until his death in 1994.

Pauling's prolific career included significant contributions to chemistry, molecular biology, biochemistry, and humanitarianism. It is easy to understand, given his accomplishments and high honors, why Pauling's story intrigues and inspires, even today. Identifying someone as a genius tends to be a bit overworked, but if there is anyone in the 20th century who demonstrated the exceptional ability and creativity associated with genius, it would have to be Linus Carl Pauling.

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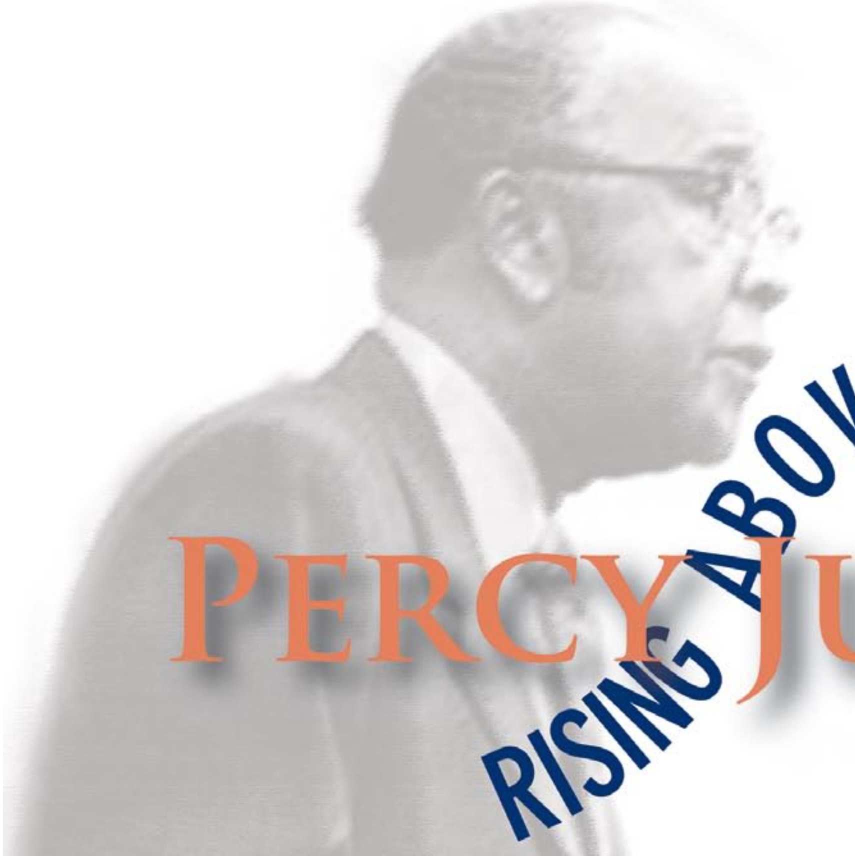
Sarah Vos is a reporter for the Lexington Herald-Leader in Lexington, KY. This is her first *ChemMatters* article.



Percy Julian
Rising Above Racism

By Christen Brownlee

On the day that Percy Julian graduated from college, his grandmother showed him, for the first time, the deep scars that ran down her shoulders. The scars were left over from a vicious beating she had received as a slave during the final days of the Civil War. Now, two generations later, slavery no longer existed in America, and Julian, an African-American man, was graduating with a chemistry degree at the top of his class. "This is worth all the scars," his grandmother said as she held his Phi Beta Kappa key.

Early life

Julian was born in 1899 in Montgomery, AL. Julian's family didn't have much money during his childhood, but he did have the encouragement of his parents—his father, a railroad mail clerk, and his mother, a school teacher. Although it was almost unheard of at the time for African-American children to go to school beyond the eighth grade, Julian's parents pushed their six children to get as much education as possible. So, when Julian graduated from high school in 1916, he applied to DePauw University in Greencastle, IN.

At that time, DePauw accepted only a few African-American students and did not permit them to live in the school's dorms. Julian managed to find an off-campus boarding house to stay for a few days when he first arrived in town. But, to his surprise, the house wouldn't serve him meals because of his race. Days passed before he found a place to eat in town. Julian eventually found a job in a DePauw fraternity house, firing the furnace and doing other odd jobs. In exchange, the fraternity let him live in the basement and eat at the house.

PHOTO COURTESY OF DEPAUW UNIVERSITY ARCHIVES

Percy Julian (rear left) with DePauw Science Club members in 1918.

Julian worked hard in school, and his efforts paid off. He graduated from DePauw University as class valedictorian. Julian intended to continue his chemistry studies by attending graduate school to earn a doctoral degree in the subject. However, he soon learned that joining a doctoral program would prove difficult. Universities across the country—whose student populations were predominantly White—denied him entrance, since, as an African-American man, the only jobs for which he'd be eligible after graduation would be teaching at universities for African-Americans.

While pondering his next step, Julian got a job teaching chemistry at Fisk University in Nashville, TN. After two years at Fisk, he won a scholarship for graduate studies in chemistry at Harvard University in Cambridge, MA. However, he was only at Harvard long enough to earn his master's degree and not the doctorate he desired. Historians speculate that the school administration would not allow him to teach White students, the most common way for doctoral students to fund their studies. Without that opportunity, Julian would not have had the money to continue attending Harvard.

After leaving Harvard, Julian found teaching positions at West Virginia State College and Howard University. However, he continued to look for creative ways to complete the graduate studies in chemistry. Julian found the answer in a fellowship he received from the Rockefeller Foundation in 1929. He decided to use the fellowship to study overseas, where he felt discrimination wouldn't be such a hardship. He continued the graduate studies started at Harvard at the University of Vienna in Austria.

Julian in the laboratory (date unknown).

PHOTO COURTESY OF DEPAUW UNIVERSITY ARCHIVES

Life in Vienna was unlike anything he'd ever known in the United States. Rather than being segregated from his peers and treated like a second-class outsider, he finally felt like a full participant at the university. He mixed and mingled at intellectual gatherings, and even started going to the opera.

Potent plants

While enjoying the freedoms that life in Austria provided, Julian worked diligently toward his doctorate. He worked to identify the structure of the active ingredients in *Corydalis cava*, an Austrian shrub that could soothe pain and ease heart palpitations. Scientists didn't know how the active ingredients in the shrub worked; however, elucidating the structures of these compounds was a logical first step.

Scientists did know that the compounds of interest were alkaloids. Alkaloids are a class of nitrogen-containing compounds found mostly in plants. Many alkaloids act as drugs. For example, caffeine, nicotine, and quinine (the oldest known antimalarial agent) are alkaloids.

To begin to solve the puzzle, Julian pulled some of the plants' alkaloids apart atom by atom and finally succeeded in identifying their structure—a first step to learning their function. The research earned him his Ph.D. in 1931, just three years after he started the program.

Magic beans

When Julian returned to the United States, he got a job as full professor and chemistry department chair at Howard University in Washington, DC. Unfortunately, he found himself embroiled in university politics and resigned after just a year. The experience wasn't totally fruitless, though—he met his future wife at Howard, and they married three years later.

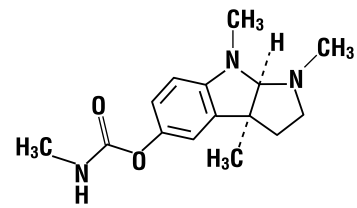
After leaving Howard, Julian wasn't sure how to revitalize his career. Eventually, he got a job as a researcher at his alma mater, DePauw University. He knew he needed to do something right away to get back on track, so he took on a risky project that would either boost his career or bring it crashing down. He decided to synthesize, or make from a set of simple ingredients, an alkaloid called physostigmine.

Julian talks with students in 1970.

PHOTO COURTESY OF DEPAUW UNIVERSITY ARCHIVES

One reason scientists synthesize chemicals already found in nature is to mass-produce them. In the process of synthesis, scientists use simple and readily available starting materials to form intermediate compounds. Through a series of chemical reactions, these intermediate compounds are transformed into the desired chemical and in much greater amounts than naturally available.

That was the case for physostigmine. Because the calabar bean, the natural source for physostigmine, contains only a tiny amount of the compound, the drug was rare and expensive. Scientists wanted more of this alkaloid to treat glaucoma, a devastating eye disease, which causes an increase in the pressure inside the eye leading to possible blindness.

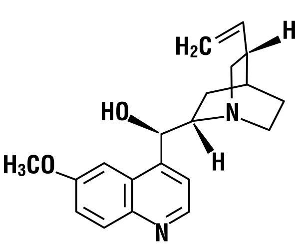


Physostigmine

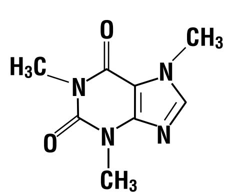
Another chemist, Sir Robert Robinson, seemed to be close to synthesizing this compound himself. Yet, Julian was sure he could beat Robinson to it. Julian brought over a friend from Vienna, a chemist named Josef Pikl, to help him with the project. Together, the two scientists worked in a frenzy to complete the synthesis before Robinson. To their disappointment, Robinson published first, claiming that he had successfully completed the synthesis of physostigmine. However, upon reading Robinson's paper, Julian and Pikl thought something looked amiss—the melting point for one of Robinson's intermediate compounds didn't match its natural counterpart.

For a synthesis to be correct, man-made compounds must match the natural compounds in every way. Even something seemingly as small as the chemical's melting point can signal whether researchers correctly synthesized the intended compound. Julian and Pikl challenged Robinson's findings and published a new paper detailing their own synthesis of physostigmine, with the melting points of physostigmine and the intermediates in its synthesis identical to the natural compounds. Their synthesis ultimately proved correct.

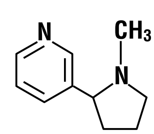
Lowly beans and other plants would prove to be the key to the rest of Julian's career. However, his success with physostigmine did not protect him from discrimination. Finding a job proved difficult, as potential employers refused to hire Julian when they learned of his race. He finally landed a job as director of research at Glidden, a paint and



Quinine



Caffeine



Nicotine

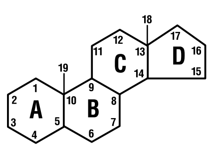
Quinine, caffeine, and nicotine belong to the class of nitrogen-containing compounds called alkaloids.

chemical company based in Chicago. Working at Glidden was a big deal—hardly any African-American chemists worked in the industry in the 1930s. Julian used his position at Glidden to investigate the soybean, a plant he was sure had untapped possibilities.

Over the next few years, he racked up hundreds of patents for products he coaxed out of soybean plants, from paper coatings to protein-rich foods to a fire-fighting spray called Aero-Foam. Aero-Foam was used by the U.S. troops during World War II to extinguish gasoline and oil fires.

His biggest accomplishment came from a mishap that could have cost him his job. Water had leaked into a tank of pure soybean oil that Julian and his colleagues used for their work. Crystals and sludge had formed in the oil; Julian and his coworkers assumed the oil, worth thousands of dollars, was spoiled. But Julian saw something promising in those crystals. When he tested them, he found stigmasterol, a steroid.

Steroids are fat-soluble compounds made of four fused carbon rings. Usually, three of the rings have six carbon molecules, and the fourth has five. There are hundreds of different steroid molecules, set apart by different chemical groups (functional groups) that hang from the carbon rings.



Steroid backbone

Julian was excited about isolating stigmasterol, a plant steroid, because it can easily be converted to an animal steroid called progesterone. Progesterone was used to prevent miscarriage in pregnant women, but it was very expensive at the time. Julian's work, the isolation of stigmasterol on a large scale,

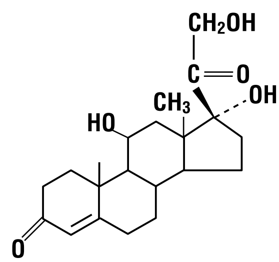
PHOTO COURTESY OF DEPAUW UNIVERSITY ARCHIVES

made the synthesis of progesterone easier and increased its availability and affordability.

Worth it

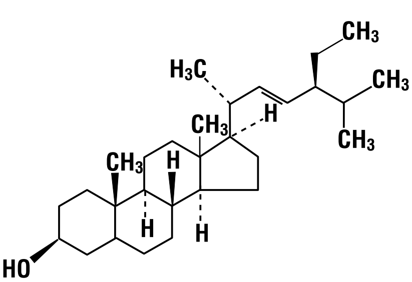
Julian was certain that the soybean plant had even more to offer, and he was right. In 1949, he announced that the plant could make another steroid that could easily be converted into a drug called cortisol. This drug worked miracles for rheumatoid arthritis sufferers—quickly easing their pain and swelling. However, like progesterone had been, cortisol was very expensive to manufacture. Another scientist had patented a process to synthesize cortisol from a starter chemical found in cow bile. However, the process took 36 steps and used expensive chemicals.

Julian found that a steroid called Reichstein's compound S (also known as Compound S) could easily be isolated from soybean oil. This compound differed from cortisol by the presence of just one oxygen atom at Carbon 11.

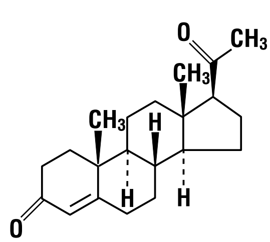


Cortisol

The challenge became finding the easiest way to add a single oxygen atom to Carbon 11 on Compound S without altering the rest of the compound. Several teams of scientists around the world worked on this task.



Stigmasterol



Progesterone

Stigmasterol was used as a starting material in the large-scale synthesis of progesterone. Stigmasterol and progesterone share the steroid backbone but differ in the groups of atoms at Carbon 3 and Carbon 17.

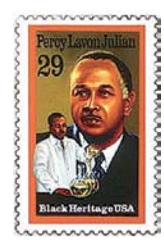
The first to identify a solution was a team of scientists at the Upjohn Company in Michigan. The Upjohn team found that a common mold had an enzyme that could supply Compound S with the oxygen atom necessary to convert it to cortisol.

By making Compound S in bulk and oxygenating it in a specific position, Julian found an easy way to mass-produce cortisol, saving several steps in the synthesis and plenty of money.

He used his success with Compound S to launch his own company, Julian Laboratories, in 1953. Julian lured talented research chemists away from Glidden and other companies to work for him making steroid intermediates from soybeans and other plants. When it was discovered that Mexican yams were a more potent source of artificial steroids, Julian opened a plant in Mexico to harvest and process yams. These yams could be used to make Compound S, which he could then sell to companies specializing in cortisol synthesis. However, he was unable to get a permit to harvest the yams, and the plant sat unused for some time. Julian found a new source of yams in Guatemala and was able to proceed with his plan.

His business quickly grew beyond anything he'd imagined. He sold his company in 1961, for \$2.3 million. The sum made him one of the richest African-American men in the country. He used some of the money to launch the Julian Research Institute, a nonprofit research organization.

After more than four decades of chemical research, Julian was elected into the National Academy of Sciences in 1973, one of the highest honors a scientist can receive. The U.S. Postal Service issued a commemorative stamp in his honor in 1993. In 1999, the American Chemical Society declared Julian's synthesis of physostigmine as one of the top 25 achievements in the history of American chemistry.



Julian died in 1975, but his legacy continues. His life's achievements—as a chemist and as a trailblazer against the racism of his time—may not be touted in the history books, but they represent a volume of improvements to the lives of everyday people.

Christen Brownlee works for Johns Hopkins University. Her article "Super Fibers" appeared in the February 2006 issue.

TRY THIS!

This year, **National Chemistry Week is October 21–27, 2007.** The theme is *The Many Faces of Chemistry*, which emphasizes the diversity of chemistry and its practitioners.

To celebrate NCW 2007, the ACS Office of High School Chemistry will launch a series of posters that highlight the careers of four individuals who, in very different ways, improve people's lives through the transforming power of chemistry.

Our posters, which feature a United States Patent and Trade Office Attorney, a Senior Scientist with 3M, a chemist with Procter & Gamble, and a licensing associate at the University of Alabama at Birmingham, were created to promote the NCW theme and our new High School Chemistry Clubs program.

But we're really interested in how YOU might communicate the importance of chemistry as a career. What kind of poster can YOU create?

IT'S YOUR TURN!

THE NCW POSTER CONTEST

As part of the **National Chemistry Week (NCW) 2007** celebration and in recognition of the 20th anniversary of the program, the American Chemical Society (ACS) is sponsoring a poster contest for students in Kindergarten–Grade 12.

Students are invited to create a poster that celebrates the theme ***"The Many Faces of Chemistry."*** The poster should be fun, motivational, and inspire students to pursue a science/chemistry-related career.

Consider how science/chemistry is used by people in different careers.

- Photographer: chemistry's role in developing film and making prints
- Artist: the chemistry of the materials used to paint, draw, or sculpt
- Veterinarian: understanding what medicines can be given to pets
- Crime Scene Investigator: investigating crimes with chemical tests

Contest Rules:

- All entries must be original works without aid from others.
- Posters must be no larger than 14 × 22 inches.
- Entries on foam board will not be accepted.
- Entries must be hand-drawn using crayons, paint, colored pencils, or markers.
- Posters must be sent to the ACS Local Section NCW Coordinator. Contact the coordinator in your area via the "Coordinator Lookup" at chemistryweek.org. ***NOTE:*** **Posters received directly from schools/students will not be eligible for the contest.**
- Posters must be submitted to NCW Coordinators in time for the local contest (deadlines will vary).

Judging:

Entries will be evaluated based on the following:

1. Artistic Merit (use of color, quality of drawing, poster design, and layout)
2. Poster Message (should be fun, motivational, and capable of inspiring students to pursue a career with an emphasis on chemistry.)
3. Originality and Creativity (unique, clever, and/or creative design)
4. Neatness (free of spelling and grammatical errors and/or stray marks)

Prizes ... Prizes ... Prizes ...

First and second place in each of the following grade categories:

- K–2
- 3–4
- 5–8
- 9–12

First Place: $250
Second Place: $150

All entries must have the following information included on the back of the poster: student's name, grade, name of school, school address, teacher's name, school telephone number, and student/teacher e-mail address. Home-schooled students are eligible for the contest and should include the name of any homeschool group with which they are associated.

Entries lacking complete and legible information will be disqualified.

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