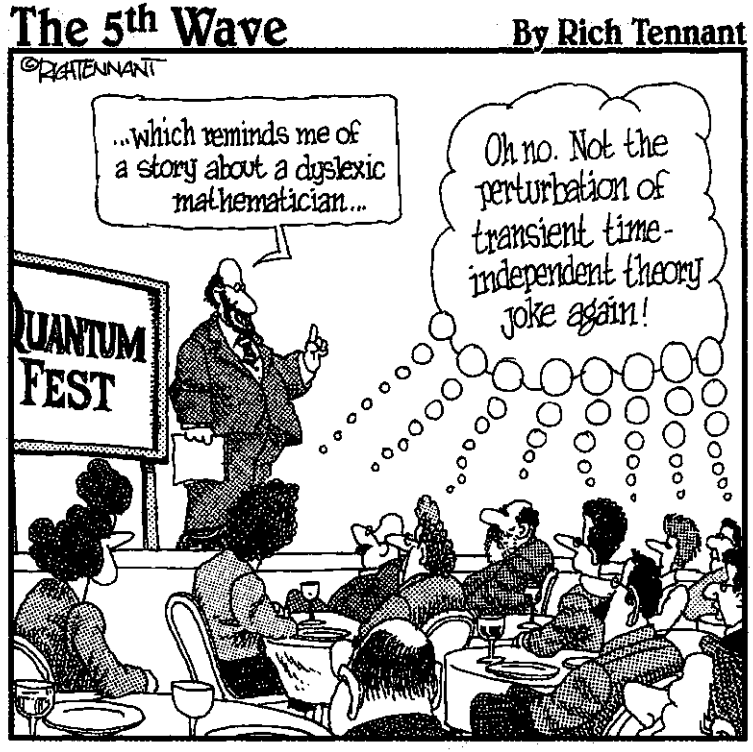
Part V
The Part of Tens



In this part . . .

Chemistry thrives on discovery. And sometimes the discoveries are accidental. The first chapter in this part shows my top-ten favorite accidental discoveries. I also present ten great chemistry nerds and ten useful chemistry Web sites that you can use to expand your knowledge.

Chapter 20

Ten Serendipitous Discoveries in Chemistry

In This Chapter

- Discovering how some discoveries are made
- Looking at some famous people of science

This chapter presents ten stories of good scientists — individuals who discovered something they didn't know they were looking for.

Archimedes: Streaking Around

Archimedes was a Greek mathematician who lived in the third century B.C. I know this is supposed to be about scientists and not mathematicians, but back then, Archimedes was as close to a scientist as you could get.

Hero, the king of Syracuse, gave Archimedes the task of determining whether Hero's new gold crown was composed of pure gold, which it was supposed to be, or whether the jeweler had substituted an alloy and pocketed the extra gold. Now Archimedes knew about density, and he knew the density of pure gold. He figured that if he could measure the density of the crown and compare it to that of pure gold, he'd know whether the jeweler had been dishonest. But although he knew how to measure the weight of the crown, he couldn't figure out how to measure its volume in order to get the density.

Needing some relaxation, he decided to bathe at the public baths. As he stepped into the full tub and saw the water overflow, he realized that the volume of his body that was submerged was equal to the volume of water that overflowed. He had his answer for measuring the volume of the crown. He got so excited that he ran home naked through the streets, yelling "Eureka, eureka!" (I've found it!) And this method of determining the volume of an irregular solid is still used today. (By the way, the crown was an alloy, and the dishonest jeweler received swift justice.)

Vulcanization of Rubber

Rubber, in the form of latex, was discovered in the early 16th century in South America, but it gained little acceptance because it became sticky and lost its shape in the heat.

Charles Goodyear was trying to find a way to make the rubber stable when he accidentally spilled a batch of rubber mixed with sulfur on a hot stove. He noticed that the resulting compound didn't lose its shape in the heat. Goodyear went on to patent the *vulcanization process,* which is the chemical process used to treat crude or synthetic rubber or plastics to give them useful properties such as elasticity, strength, and stability.

Right- and Left-Handed Molecules

In 1884, the French wine industry hired Louis Pasteur to study a compound left on wine casks during fermentation — racemic acid. Pasteur knew that racemic acid was identical to tartaric acid, which was known to be *optically active* — that is, it rotated polarized light in one direction or another.

When Pasteur examined the salt of racemic acid under a microscope, he noticed that two types of crystals were present and that they were mirror images of each other. Using a pair of tweezers, Pasteur laboriously separated the two types of crystals and determined that they were both optically active, rotating polarized light the same amount but in different directions. This discovery opened up a new area of chemistry and showed how important molecular geometry is to the properties of molecules.

William Perkin and a Mauve Dye

In 1856, William Perkin, a student at The Royal College of Chemistry in London, decided to stay home during the Easter break and work in his lab on the synthesis of quinine. (I guarantee you that working in the lab isn't what my students do during their Easter break!)

During the course of his experiments, Perkin created some black gunk. As he was cleaning the reaction flask with alcohol, he noticed that the gunk dissolved and turned the alcohol purple — mauve, actually. This was the synthesis of the first artificial dye. As luck would have it, mauve was "in" that year, and this dye quickly became in great demand. So Perkin quit school and, with the help of his wealthy parents, built a factory to produce the dye.

Now if this were the entire story, it would've had little effect on history. However, the Germans saw the potential in this chemical industry and invested a great deal of time and resources in it. They began building up and investigating great supplies of chemical compounds, and soon Germany led the world in chemical research and manufacturing.

Kekule: The Beautiful Dreamer

Friedrich Kekule, a German chemist, was working on the structural formula of benzene, C_6H_6, in the mid-1860s. Late one night he was sitting in his apartment in front of a fire. He began dozing off and, in the process, saw groups of atoms dancing in the flames like snakes. Then, suddenly, one of the snakes reached around and made a circle, or a ring. This vision startled Kekule to full consciousness, and he realized that benzene had a ring structure. He stayed up all night working out the consequences of his discovery. Kekule's model for benzene paved the way for the modern study of aromatic compounds.

Discovering Radioactivity

In 1856, Henri Becquerel was studying the *phosphorescence* (glowing) of certain minerals when exposed to light. In his experiments, he'd take a mineral sample, place it on top of a heavily wrapped photographic plate, and expose it to strong sunlight.

He was preparing to conduct one of these experiments when a cloudy spell hit Paris. Becquerel put a mineral sample on top of the plate and put it in a drawer for safekeeping. Days later, he went ahead and developed the photographic plate and, to his surprise, found the brilliant image of the crystal, even though it hadn't been exposed to light. The mineral sample contained uranium. Becquerel had discovered radioactivity.

Finding Really Slick Stuff: Teflon

Roy Plunkett, a Du Pont chemist, discovered Teflon in 1938. He was working on the synthesis of new refrigerants. He had a full tank of tetrafluoroethylene gas delivered to his lab, but when he opened the valve, nothing came out. He wondered what had happened, so he cut the tank open. He found a white substance that was very slick and unreactive. The gas had polymerized into the substance now called Teflon. It was used during World War II to make gaskets and valves for the atomic bomb processing plant. After the war, Teflon finally made its way into the kitchen as a nonstick coating for frying pans.

Stick 'Em Up!! Sticky Notes

In the mid-1970s, a chemist by the name of Art Frey was working for 3M in its adhesives division. Frey, who sang in a choir, used little scraps of paper to keep his place in his choir book, but they kept falling out. At one point, he remembered an adhesive that had been developed but rejected a couple years earlier because it didn't hold things together well. The next Monday, he smeared some of this "lousy" adhesive on a piece of paper and found that it worked very well as a bookmark — and it peeled right off without leaving a residue. Thus was born those little yellow sticky notes you now find posted everywhere.

Growing Hair

In the late 1970s, Minoxidil, patented by Upjohn, was used to control high blood pressure. In 1980, Dr. Anthony Zappacosta mentioned in a letter published in *The New England Journal of Medicine* that one of his patients using Minoxidil for high blood pressure was starting to grow hair on his nearly bald head.

Dermatologists took note, and one — Dr. Virginia Fiedler-Weiss — crushed up some of the tablets and made a solution that some of her patients applied topically. It worked in enough cases that you now see Minoxidil as an over-the-counter hair-growth medicine.

Sweeter Than Sugar

In 1879, a chemist by the name of Fahlberg was working on a synthesis problem in the lab. He accidentally spilled on his hand one of the new compounds he'd made, and he noticed that it tasted sweet. (Wouldn't the government's Occupational Safety and Health Administration (OSHA) have loved that!) He called this new substance *saccharin*.

James Schlatter discovered the sweetness of *aspartame* while working on a compound used in ulcer research. He accidentally got a bit of one of the esters he'd made on his fingers. He noticed its sweetness when he licked his fingers while picking up a piece of paper.

Chapter 21

Ten Great Chemistry Nerds

In This Chapter

- Finding out how some scientists have influenced the field of chemistry
- Discovering some great discoveries
- Accepting the role of individuals in science

Science is a human enterprise. Scientists draw on their knowledge, training, intuition, and hunches. (And as I show you in Chapter 20, serendipity and luck come into play, also.) In this chapter, I introduce you to ten scientists who made discoveries that have advanced the field of chemistry. There are literally hundreds of choices, but these are mine for the top ten.

Amedeo Avogadro

In 1811, the Italian lawyer-turned-scientist Avogadro was investigating the properties of gases when he derived his now-famous law: Equal volumes of any two gases at the same temperature and pressure contain the same number of particles. From this law, the number of particles in a mole of any substance was determined. It was named Avogadro's number. Every chemistry student and chemist has Avogadro's number. Do you? See Chapter 10 if you don't.

Niels Bohr

Niels Bohr, a Danish scientist, used the observation that elements, if heated, emit energy in a set of distinct lines called a *line spectrum* to develop the idea that electrons can exist only in certain distinct, discrete energy levels in the atom. Bohr reasoned that the spectral lines resulted from the transition between these energy levels.

Bohr's model of the atom was the first to incorporate the idea of energy levels, a concept that's now universally accepted. For his work, Bohr received the Nobel Prize in 1922.

Marie (Madame) Curie

Madame Curie was born in Poland, but she did most of her work in France. Her husband, Pierre, was a physicist, and both were involved in the initial studies of radioactivity. Marie discovered that the mineral pitchblende contained two elements more radioactive than uranium. These elements turned out to be polonium and radium. Madame Curie coined the term *radioactivity*. She and her husband shared the Nobel Prize with Henri Becquerel in 1903.

John Dalton

In 1803, John Dalton introduced the first modern atomic theory. He developed the relationship between elements and atoms and established that compounds were combinations of elements. He also introduced the concept of atomic mass.

Unlike many other scientists who had to wait many years to see their ideas accepted, Dalton watched the scientific community readily embrace his theories. His ideas explained several laws that had already been observed and laid the groundwork for the quantitative aspects of chemistry. Not too bad for an individual who started teaching at the age of 12!

Michael Faraday

Michael Faraday made a tremendous contribution to the area of electrochemistry. He coined the terms *electrolyte, anion, cation,* and *electrode*. He established the laws governing electrolysis, discovered that matter has magnetic properties, and discovered several organic compounds, including benzene. He also discovered the magnetic induction effect, laying the groundwork for the electric motor and transformer. Without Faraday's discoveries, I may have had to write this book with a quill pen by lamplight.

Antoine Lavoisier

Antoine Lavoisier was a careful scientist who made detailed observations and planned his experiments. These characteristics allowed him to relate the process of respiration to the process of combustion. He coined the term *oxygen* for the gas that had been isolated by Priestly. His studies led him to the Law of Conservation of Matter, which states that matter can neither be created nor destroyed. This law was instrumental in helping Dalton develop his atomic theory. Lavoisier is sometimes called the father of chemistry.

Dmitri Mendeleev

Mendeleev is regarded as the originator of the periodic table, a tool that's indispensable in chemistry. He discovered the similarities in the elements while preparing a textbook in 1869. He found that if he arranged the then-known elements in order of increasing atomic weight, a pattern of repeating properties emerged. He used this concept of *periodic,* or repeating, properties to develop the first periodic table.

Mendeleev even recognized that there were holes in his periodic table where unknown elements should be found. Based on the periodic properties, Mendeleev predicted the properties of these elements. Later, when gallium and germanium were discovered, scientists found that these elements had properties that were very close to those predicted by Mendeleev.

Linus Pauling

If Lavoisier is the father of chemistry, then Linus Pauling is the father of the chemical bond. His investigations into the exact nature of how bonding occurs between elements were critical in the development of our modern understanding of bonding. His book, *The Nature of the Chemical Bond,* is a classic in the field of chemistry.

Pauling received a Nobel Prize in 1954 for his work in chemistry. He received another Nobel Prize, for peace, in 1963 for his work on limiting the testing of nuclear weapons. He's the only individual to receive two unshared Nobel Prizes. (He's also well known for his advocacy of using megadoses of Vitamin C to cure the common cold.)

Ernest Rutherford

Although Rutherford is perhaps better classified as a physicist, his work on the development of the modern model of the atom allows him to be placed with chemists.

He did some pioneer work in the field of radioactivity, discovering and characterizing alpha and beta particles — and received a Nobel Prize in chemistry for this work. But he's perhaps better known for his scattering experiments in which he realized that the atom was mostly empty space and that there had to be a dense, positive core at the center of the atom, which is now known as the nucleus. Inspired by Rutherford, many of his former students went on to receive their own Nobel Prizes.

Glenn Seaborg

Glenn Seaborg, while working on the Manhattan Project (that's the atomic bomb project), became involved in the discovery of several of the *transuranium elements* — elements with an atomic number greater than 92. Seaborg came up with the idea that the elements Th, Pa, and U were misplaced on the periodic table and should be the first three members of a new rare earth series under the lanthanides.

After World War II, he published his idea, which was met with strong opposition. He was told that he would ruin his scientific reputation if he continued to express his theory. But, as he said, he had no scientific reputation at that point. He persevered and was proven correct. And he received the Nobel Prize in 1951.

That Third-Grade Girl Experimenting with Vinegar and Baking Soda

This third-grade girl represents all those children out there who, each and every day, are making great discoveries. They explore the world around them with magnifying glasses. They pry open owl pellets and see what animals the owl ate. They experiment with magnets. They watch while baby animals are being born. They build vinegar-and-baking-soda volcanoes. They discover that science is fun.

They listen when they're told that scientists must keep on trying and that they must not give up. Their parents and teachers encourage them. They aren't told that they can't do science. If they are, they don't believe it.

They ask questions, lots of questions. They love the diversity of science, and they appreciate the beauty of science. They may never become professional scientists themselves, but they'll sit at the dining room table someday, laughing and joking with their kids as they help them build vinegar-and-baking-soda volcanoes.

Chapter 22

Ten Useful Chemistry Web Sites

In This Chapter

- Looking for Web sites related to chemistry
- Surfing the sites for the chemical information you want
- Navigating through additional links that you find

The Web is a gold mine of useful information, with a lot of fool's gold thrown in. In this chapter, I provide you with some good starting places to find cool chemical information. Because Web sites come and go, I'm not promising that all, or even any, of these sites will be there when you start looking for them, but I tried to choose ones that have a good chance of being around. (Even though I know people who wish the EPA would go away, it's quite likely that it'll still be there.) Use the additional links that you find at each site to branch out and fulfill your interest in chemistry.

American Chemical Society

`www.acs.org/portal/Chemistry`

The American Chemical Society (ACS) is the largest scientific organization in the world devoted to a single scientific discipline. Its Web site offers a wealth of information and links to other sites. A chemical search engine is available, along with a molecule of the week. It has links to chemistry-related news stories, an online store (if you simply *must* have that coffee cup made out of a beaker — I have two!), and links to various divisions within the American Chemical Society. You can even join the ACS online.

Material Safety Data Sheets

http://siri.uvm.edu/msds/

A Material Safety Data Sheet (MSDS) provides a wealth of information concerning the safe handling, spill control, health hazards, and so on, of a chemical. Most places are required by law to maintain an MSDS for every chemical in stock. At this site, you can search by name, product name, or CAS (Chemical Abstracts Service) registry number for an MSDS on a particular chemical and then print it out. This site also provides lots of information about chemicals, as well as links to other Internet MSDS sites and hazardous chemical reference sites.

U.S. Environmental Protection Agency

www.epa.gov/

This is the official EPA site. It has links to lots of information concerning the environment, hazardous chemicals, and such. You can browse through environmental laws and regulations, read the latest news articles concerning environmental issues, and check the status on toxic substances such as lead. The site even features a For Kids section that explains environmental issues in a way that's appropriate for children. You can order EPA publications online and obtain educational materials, too. It's your tax dollar — get the most out of it.

Chemistry.About.Com

www.chemistry.about.com/

Chemistry.about.com is a commercial Web site geared to a wide range of ages. It has a section on homework for those in high school and college, a description of scientific toys, links to companies that sell scientific equipment, and links to the specific areas of chemistry: organic, physical, analytical, and so on. One of the most useful sets of links is to chemistry clip art. Beware, though: This site can be frustrating because of the advertising windows that keep opening. If you can deal with that aspect, this is a good general site.

Webelements.com

www.webelements.com/

This great British Web site is set up as a periodic table. Want to know something about the element tantalum? What about osmium? Need the melting point of zinc? Just click on an element, and you get all its pertinent physical properties and common compounds — and in most cases, you even get a photograph of it. This Web site also keeps you up to date on the discovery of new elements. You can even print a copy of the periodic table. This site definitely belongs on your favorites list.

Plastics.com

www.plastics.com/

Plastics.com is primarily for those who want to know a little more about plastics or are in the plastics industry. This site has numerous news articles about current events in the industry, and you can get information about many different types of plastics. This is a great Web site for someone with an upcoming job interview at a plastics-related company.

Webbook

http://webbook.nist.gov/

This site from the National Institute of Standards and Technology is a great source of data on thousands of chemical compounds. You can access *thermochemical data* (data dealing with the relationship of heat in chemical reactions) on more than 6,000 organic and inorganic compounds, and you can get infrared, *mass spectrum* (the spectrum of a stream of gaseous ions separated according to their mass and charge — it's a way to identify the chemical constitution of a substance), and ultra violet and visible *(UV/Vis)* spectra (another way to determine the structure of molecules using energy) for numerous compounds. You can search the database by name, formula, CAS number, molecular weight, or numerous other properties.

ChemClub.com

www.chemclub.com/

ChemClub is a commercial site that provides access to a broad range of information about chemistry in general. It has numerous links to search engines, current events related to chemistry, and more. This well-developed site is useful to chemistry professionals or members of the general public who want an overall view of industrial chemistry.

Institute of Chemical Education

http://ice.chem.wisc.edu/

The Institute of Chemical Education (ICE) is associated with the University of Wisconsin. Its main emphasis is training in-service teachers. The institute's Web site has links to other chemical-education sites. Information concerning the institute's workshops and other presentations is available, too.

The Exploratorium

www.exploratorium.edu/

The Exploratorium, the "museum of science, art, and human perception," in San Francisco, California, is one of the foremost science museums in the country. This must-see Web site is geared toward kids and families. It's updated daily with news articles and current events. You can learn the science behind baseball, hockey, and other sports in its *Sports! Science* feature. The site presents a lot of activities for kids and adults in all the areas of science. The Exploratorium publications have been among my favorites for years.