BIG Little Science Centre

Newsletter 55 February 2005

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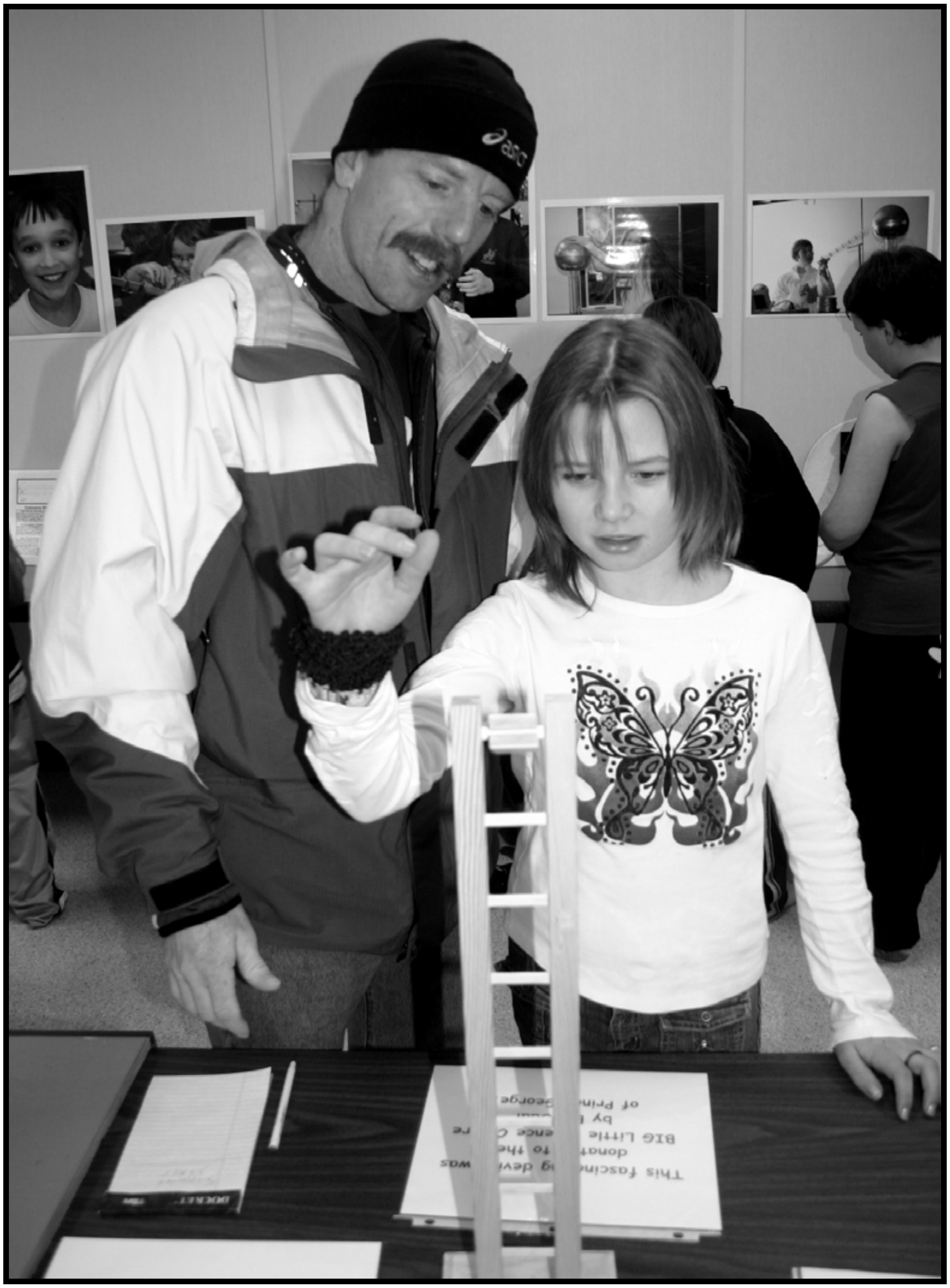


Doug Miller and **Danielle Thompson** experiment with the **'Magic Ladder'**. Danielle was visiting with **Frank Law**'s class from **Arthur Hatton Elementary School.**

Everyday Chemistry
Aluminum
Jim Hebden, PhD

Let's pretend that you are Emperor Napoleon III of France in 1855. As the Emperor of one of the most powerful nations on earth, you look with pride at the new plates that just arrived for your state dinner with the ambassador of England. Lovingly, you run your hands over the shiny plates, made from the newest precious metal. This metal is so precious that as Emperor you have become the chief 'financial backer' of a French chemist who has created a refining plant to make small amounts of the precious metal. Under your leadership, France is now the world's leading producer of this metal, which is more precious than gold and platinum. In fact, a one-kilogram bar of this metal has just been placed on display at the Paris Exposition, exciting all those who are privileged to see it. Your new plates, made from **aluminum**, will be the talk of the continent! *Wait a minute! Did you say aluminum*? Yes! *A precious metal?* Well, in 1855 it was a precious metal and remained so until 1886, when two French and American chemists simultaneously discovered a way to produce aluminum on a large scale by passing electricity through a melted aluminum ore called **bauxite**. (Incidentally, how precious would gold be if it were more common and cheaper than iron?)

You probably think that aluminum is a pretty boring metal, but then you have never actually seen aluminum. Oh, I know you THINK you have seen aluminum, but you haven't. Aluminum is an extremely reactive metal, which instantly reacts with oxygen in the air, creating a thin layer of **aluminum oxide** on the surface of the aluminum. What you have seen is a somewhat dull oxide layer, partly hiding the shiny, silver-coloured metal underneath. That is the reason aluminum usually doesn't seem to be as shiny as polished gold or silver. Aluminum oxide is actually pretty interesting stuff on its own. Natural crystals of aluminum oxide are called corundum, emery, sapphire or ruby, depending on the impurities present. Although pure aluminum oxide crystals are transparent and colourless, the presence of various impurities give the gray to black colour of **corundum** and **emery**, chromium impurities produce **rubies** and a combination of iron and chromium impurities produce **sapphires**. By melting pure aluminum oxide and adding various impurities, scientists can now routinely make rubies and sapphires that weigh several hundred kilograms.

Aluminum production requires vast amounts of cheap electrical energy, so that when the **Alcan Company** built an aluminum smelter at **Kitimat** they also built the **Kemano** dam to provide the electricity needed. You have probably seen the electrical wires in your home. Typically, those copper wires carry a maximum of about 20-30 amperes of electricity and are about 2 mm in diameter. The amount of electricity used at Kitimat is so huge that the "wires" are actually copper bars about 30 cm (1 foot) wide and 60 cm (2 feet high), and carry about 10 million amperes! Because aluminum melts at a relatively low temperature (660^{o}C), recycling of aluminum is easy and very cost effective. For example, recycling one kilogram of scrap aluminum requires only 3.3% of the energy needed to produce one kilogram of aluminum from aluminum ores.

Aluminum is the most abundant metal in the earth's crust and is valued for its strength, lightness and malleability (ability to be rolled into very thin sheets). Its strength and lightness make it especially valuable for aircraft and rockets. In addition, aluminum is a moderate electrical conductor, which is over 3 times lighter than copper and is used extensively in long distance electrical transmission lines. Unfortunately, aluminum wires have a poor safety record in houses. The joint between the aluminum wires and various fixtures such as electrical outlet boxes can corrode and build up a thick layer of aluminum oxide. Since aluminum oxide is an electrical insulator, the resulting joint gets very hot and more than a few house fires started from such faulty joints.

Aluminum foil can be used to clean tarnished silver. You can buy an expensive bar of aluminum that is advertised as a special aluminum alloy acting as a 'magnet' for silver tarnish. In fact, the bar has no magnetic properties, and works no better than the following inexpensive and simple method. Line the inside of a large pan with a large piece of aluminum foil. Next, place a few pieces of tarnished silverware in the pan, fill the pan half full of water, add a couple of teaspoons of baking soda to the water and gently heat the pan and its contents until the water is hot. The baking soda strips off the aluminum oxide layer from the aluminum metal and the aluminum then reacts with the tarnish on the silver, producing tarnish-free silver. Although this method works as well as the commercial tarnish 'magnet', regular silver polish works even better and quicker.

Aluminum does not tarnish or corrode easily because of the tough aluminum oxide layer coating it. However, there are two ways in which aluminum reacts with nasty consequences. Aluminum and salt are a bad combination. The **chloride** ions present in salt (sodium **chloride**) disrupt the aluminum oxide layer, allowing quick corrosion of the underlying aluminum metal. That is why aluminum boats have a short life in the salty oceans. (Some large commercial fishing boat hulls are made of aluminum BUT they have an electrical generator going constantly to counteract the electrochemical corrosion process.) The other way in which aluminum reacts can be seen when it is exposed to high temperatures, water and flames: it burns quickly. During the Falkland Islands War, a British warship was struck by a missile. The resulting explosion caused a fire to start. The upper part of the ship, called the “superstructure” was made of a strong and lightweight type of aluminum. The unfortunate seamen tried to put out the fire by spraying the burning aluminum with water, causing the aluminum to burn even more strongly. Eventually the ship sank. The American navy, which had started to build new aluminum superstructures on their warships, saw the results of the British disaster and quickly replaced the brand-new aluminum with equally strong but much more expensive stainless steel. Both Britain and the United States should have talked to a chemist beforehand and saved themselves a couple of billion dollars!

Although its aluminum oxide layer protects aluminum under most conditions, aluminum can be made more useful by a process called **anodization**. Anodization involves placing aluminum in an acid solution and passing an electrical current through the aluminum to increase the thickness of the tough oxide layer. Because the new layer is quite porous, special dyes can be added to actually colour the aluminum. Anodized aluminum is very tough and unreactive … provided the surface of the aluminum doesn’t make contact with basic solutions (such as baking soda in water) or salty solutions.

Aluminum can be vaporized at a relatively low temperature in a vacuum and this vapour condenses on any object it touches, so that a thin layer of aluminum metal can form a shiny, heat- and light-reflective coating on mirrors, decorative paper and plastic toys. Aluminum-coated mylar plastic has saved the lives of several people who were lost in freezing conditions. By wrapping themselves with the heat-reflective plastic sheet, they were able to survive temperatures that would have otherwise threatened their lives. The heat-reflective property of these same sheets has also saved the lives of several fire fighters who were trapped when a forest fire roared down on top of them, cutting off their escape. By staying in a depression in the ground, covered by the plastic, the fire fighters were protected when the heat wasn’t able to fully penetrate the blanket.

Well, do you still think aluminum is a boring metal?

Gypsum Wallboard

by David McKinnon, PhD

Gypsum wallboard has been the industry standard for wall construction in housing for at least a generation, and has replaced older methods based on lime or cement plaster. Gypsum is softer than these, but this is not a disadvantage as it allows easy cutting for installation, easy fastening by nails or screws, and further domestic activities such as picture hanging. Gypsum has also low thermal conductivity, so it adds some insulation value. The boards are rigid, but if carefully dampened, can be slowly bent over moderate curves. Too much water causes damage to the boards.

The manufacture of the wallboard relies on some chemical properties of the mineral **gypsum**. This has the chemical composition $CaSO_4 \cdot 2H_2O$, which means that every calcium sulfate ($CaSO_4$) molecule is associated with two water molecules, often called 'water of crystallization'. This form is known as the **dihydrate**,

Gypsum is a common mineral, and occurs in large beds. It is also called **evaporite**, as it is thought to have been formed by precipitation of calcium sulfate from evaporating seas in geological times. Several varieties are available, known as **selenite, satin spar**, **alabaster**, etc. Some of these minerals are quite attractive and figure in mineral collections. Curved crystals are sometimes formed. These are easily scratched, even by a fingernail, as the mineral ranks only 2 on the Moh hardness scale of minerals.

When heated, gypsum readily loses some of its water of crystallization forming the **hemihydrate** $(CaSO_4)_2 \cdot H_2O$, which contains one water molecule for every two calcium sulfate molecules. When the powdered hemihydrate is mixed with the right amount of water, it rapidly reforms a solid mass held together by interlocking fine crystals of the dihydrate. For the manufacture of wallboard, a freshly mixed slurry of the hemihydrate/water is rolled between two sheets of paper on a continuous process. It rapidly sets to a smooth and rigid material. The setting time can be controlled by the addition of cellulose-based retarders if necessary. The hemihydrate is also known as **'Plaster of Paris'** as the dihydrate from which it was formed was mined in the Montmartre area of Paris.

Calcium sulfate also occurs as the mineral **anhydrite**, which contains no water. This is thought to have been formed by slow loss of water from gypsum. The process can be hurried by heating gypsum at 360° C. When pure, anhydrite forms an attractive pale blue mineral called **angelite**. The reverse process (rehydration to gypsum) is not easy. It could probably be hurried by heating powdered anhydrite with water, but as gypsum is plentiful, there is no economic need.

Gypsum is not too soluble in water, but enough dissolves so that if you wash your hands after working with it, you will form a soap scum, by reaction of the calcium ion with the soap. The mineral is also used to improve soils, acting as a source of both calcium and sulfur, and improving heavy clays.

Science Fun for Your Family

Eggs-act Science

Which egg is raw? Which is hardboiled?

Puzzle: You have two chicken eggs, one raw and one hardboiled. How can you tell which is which, without breaking the eggs open?

What to Do

- Try spinning the eggs with the same force. Does one spin faster and easier than the other?
- Place a tablecloth or napkin under the eggs. Which of the eggs can be made to stand vertically like the egg on the left in the photograph?
- If you know which egg is 'raw', try shaking it for about 30 seconds, then try these experiments again.

A hardboiled egg has most of its mass concentrated in the yoke, which will be 'fixed' in position. The hardboiled egg spins more easily around its centre of gravity. The yoke in the raw egg sloshes back and forth when you spin the egg, and this slows down the spinning. In a 'shaked' raw egg the yoke can flow downward to whichever end is lower, and this lowers the centre of gravity of the egg, so it is possible to stand a 'shaked' raw egg on its 'head'.

Caution! *If you break the egg, the yoke's on you!*

Idea Source: *Tik Liem*, **Invitations to Science Inquiry** Supplement page 107**.**
(Science Inquiry Enterprises, 14358 Village View Lane, Chino Hills, CA 911709)

Action at the BIG Little Science Centre
School District 73 Gifted Group Pays a Visit

Riley Polacik gets a real charge out of the Van de Graaff generator.

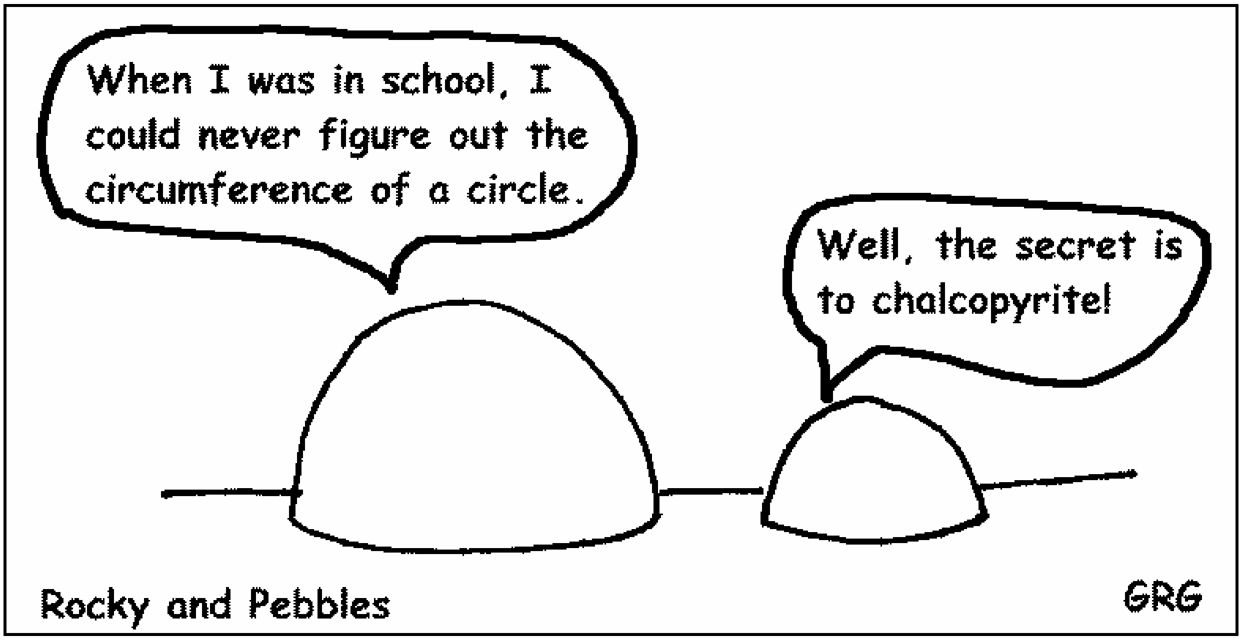
Director **Eric Wiebe** makes the Chinese Singing Bowl sing (and splash!).

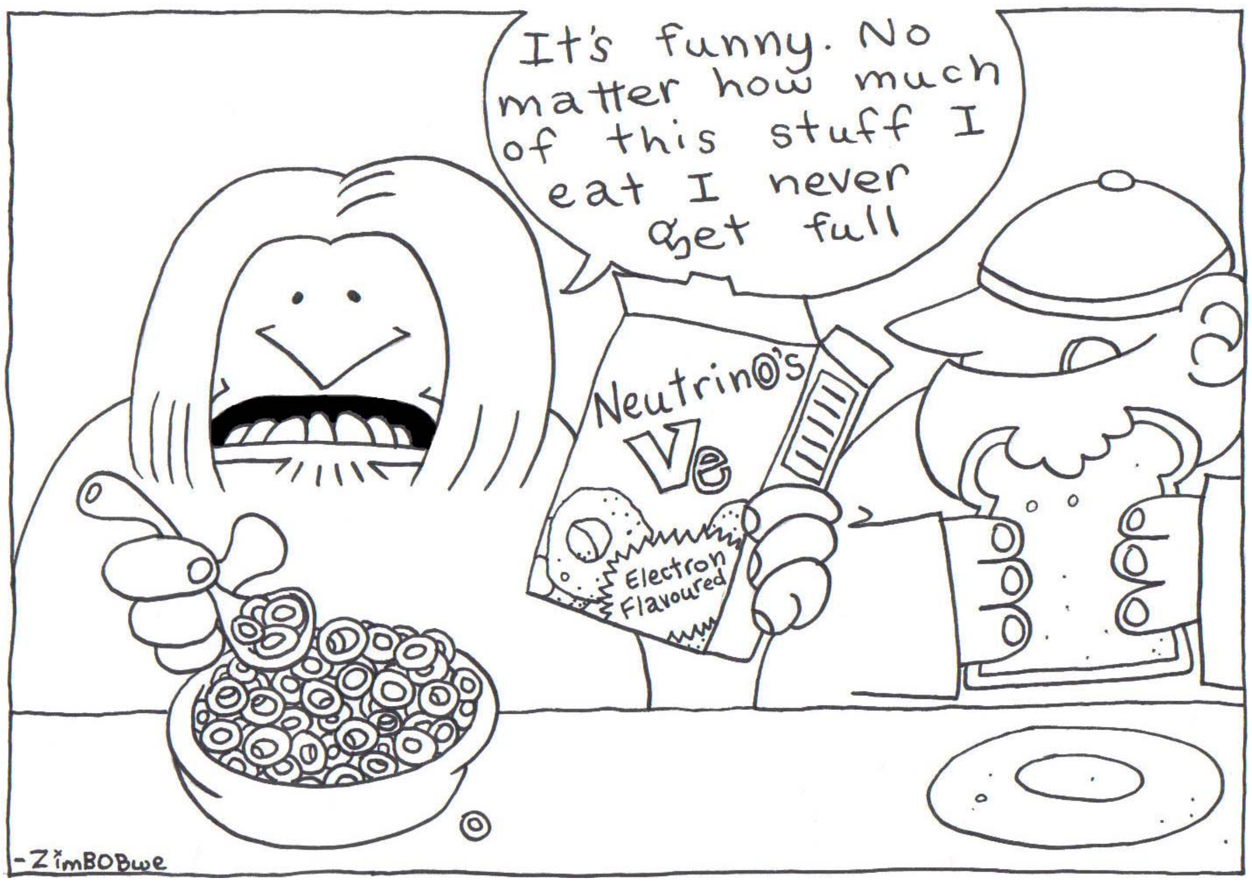
Demonstrator **Ken Schroeder** makes water 'disappear'.

Left: Are two marbles better than one? (**Alex Campbell** experiments.) *Right:* **Skye Griffith** soaks in words of wisdom from chemistry wizards **Ken Schroeder** and **Dave McKinnon**.

Courtney Ranger enjoys a hair-raising experience.

Curtis Bogetti uses the 'spy microphone' to hear what's happening in the next room.





Ehren Stillman Cartoon

Join the BIG Little Science Centre Society!

*Fill out this form and mail it and your check for **$20***
*(made out to **BIG Little Science Centre Society**) to*
BIG Little Science Centre Society, c/o 962 Sicamore Drive, Kamloops, BC V2B 6S2.

You will be placed on the membership list and receive our newsletter.

_____ I wish to become a ***NEW MEMBER*** of the **BIG Little Science Centre Society.**

_____ I wish to ***RENEW MY MEMBERSHIP*** in the **BIG Little Science Centre Society.**

______ *I wish to make an **ADDITIONAL DONATION** of $_______, for which I shall receive an **income tax receipt** for my charitable contribution to the society.*

Name ____

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Next **BIG Little Science Centre Society** Meeting
Thursday March 3, 2005
7:00 P.M. in the Isaac Newton Room
David Thompson Elementary School

Spring Open House April 16
Please mark your calendar now!

Total Newsletter Circulation Count *to January 31, 2005: 127*
Visitor Count to January 31 2005: Since September 2004: 2,571
Visitor Count Since Opening in February, 2000: 18,500