

Elemental, My Dear Holmes, Elemental



Even Sherlock Holmes did not deduce that man would someday reach for Mars. But with all of the scientific data available on the Internet, you can be your own Sherlock and investigate some of the mysteries of Mars and the human body.

By Bob Allbrecht
and Paul Davis

Subject: Math, science

Grade Level: 5–12 (Ages 10–18)

Technology: Internet/Web, spreadsheets (e.g., Microsoft Excel)

Standards: NETS•S 3. (Read more about the NETS Project at www.iste.org—select Standards Projects.)

Online Supplement: attached

Turning to his esteemed friend and colleague, Sherlock Holmes asked, “Dr. Watson, Homo sapiens is a marvelous manifestation of nature’s handiwork. But exactly what are the fundamental constituents of the human body?”

“Elemental, my dear Holmes, elemental,” replied Watson. “The human body consists mostly of the elements oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus, plus tiny amounts of other elements.”

“Aha!” eurekaed Holmes. “Tell me more.”

Unfortunately, at this moment the recording device in our tiny eavesdropping time machine malfunctioned, and it was unable to record Watson’s reply. (See *Elementary, My Dear Watson*, *Elementary* on p. 26.)

What might Dr. Watson know about, for example, the percentages by mass of the elements of the human body? We think that he would know about such things in his time. And just what is that time? We found a time line of events in the lives of Sir Arthur Conan Doyle and his fictional characters Sherlock Holmes, Dr. John H. Watson, and Professor Moriarty at <http://home.pacbell.net/klingerl/Chrotabl.htm>.

Holmes met Dr. Watson in 1881 and, in the same year, took up residence at 221B Baker Street. This occurred in the first Sherlock Holmes story, “A Study in Scarlet.” More Internet meandering rewarded us with *Mystery Greats: Time Line: Sherlock Holmes* (www.mysterynet.com/holmes/timeline) where we learned that

“A Study in Scarlet” was published in 1887.

When Holmes and Watson first met in 1881, more than 60 elements were known, and Dimitri Mendeleev had published his periodic table of the elements. Holmes and Watson, being the scientists they were, certainly knew about this. Watson was probably able to reply to Holmes’s question with estimates of the percentages by mass of the elements of the human body. We looked for this data and found it at www.modlife.com/MLG/body.html.

Here you’ll find a table listing 16 of the elements of the human body, their percentages by weight, the weight of each element in a 150-pound body, and other interesting data. After visiting this site and consulting some chemistry books, we made Figure 1 showing the percentages by mass of six elements that make up 99% of the human body. We added a category called “Other” for the 1%, which includes potassium, sulfur, sodium, chlorine, fluorine, magnesium, iron, manganese, silicon, and iodine.

Most of the body’s elements occur in chemical compounds such as water,

carbohydrates, proteins, fats, and bone. For example, much of the oxygen and hydrogen is in the form of water, good old H₂O. The body’s mass is 60% water. A 70-kilogram (154-pound) person contains 42 kilograms (92.4 pounds) of H₂O. One kilogram of water has a volume of one liter, so a 70-kilogram person contains 42 liters of water, enough to fill 21 two-liter soda bottles.

Activity

Make a table and bar chart showing the masses in kilograms of the elements in your body. A spreadsheet is a great tool for this task. Use a metric scale to get your mass in kilograms and use the percentage data in Figure 1 to calculate the mass of each element in your body. If you don’t have a metric scale, use this conversion: On Earth’s surface, a 1-lb weight has a mass of 0.454 kg.

Investigation

What are the chemical formulas and structures of the water, fats, carbohydrates, proteins, and bones in an “average” human body? What are these percentages in the body of a person who

eats the right stuff and exercises a lot? What are the percentages in the body of a TV-watching couch potato? What are the percentages in your body? Make a table and bar chart showing the percent by mass of water, fats, carbohydrates, proteins, and bone in the human body of your choice. Again, a spreadsheet is a great tool for this task.

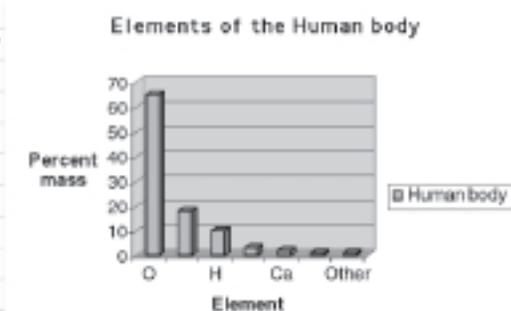
Earth & Mars: Elements of the Atmospheres

If you’ve been reading this column, you know that we are participating in the Mars Millennium Project (www.mars2030.net), which challenges students across the nation to design communities on Mars for the year 2030. To survive and thrive on Mars, humans must be able to obtain the stuff of life from resources on Mars such as its atmosphere and crust (the outer layer of the planet, including the surface).

What are the elements and compounds in the atmospheres of Earth and Mars? You can find data about the atmospheres of Earth and other planets at the National Space Sciences Data Center. We visited NSSDC’s Earth

Fact Sheet (<http://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html>) and Mars Fact Sheet (<http://nssdc.gsfc.nasa.gov/planetary/factsheet/marsfact.html>). Using data from these sources, we created Figure 2 showing percentages by volume of dry air of components of Earth’s and Mars’s atmospheres.

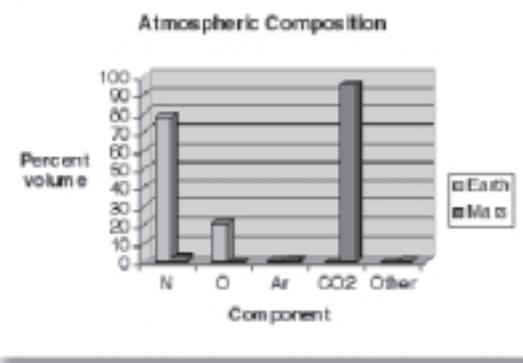
Element	Symbol	Human body
Oxygen	O	65
Carbon	C	18
Hydrogen	H	10
Nitrogen	N	3
Calcium	Ca	2
Phosphorus	P	1
Other	Other	1
Total		100



Earth & Mars: Atmospheric Composition

Component	Symbol	Earth	Mars
Nitrogen	N	78.084	2.7
Oxygen	O	20.946	0.13
Argon	Ar	0.934	1.6
Carbon dioxide	CO ₂	0.035	95.32
Other	Other	0.001	0.25

Figure 2. Composition of Earth's and Mars's atmospheres (dry air).



Earth & Mars: Atmospheric Conditions

The air you breathe on Earth is 78% nitrogen and 21% oxygen at a sea-level pressure of 1,013 millibars (1 atmosphere). The average outdoor temperature is a comfortable 15 °C (59 °F), and Earth's temperature range is approximately -60 °C (-76 °F) to +60 °C (140 °F). In July, it's really hot in Death Valley, California, and very cold in Antarctica. By wearing appropriate clothing, you can survive outdoors almost anywhere on Earth.

The atmospheric pressure on Mars is 6 to 9 millibars—less than 1% of Earth's—and its "air" is 95% carbon dioxide. The average temperature on Mars is -63 °C (-81.4 °F), and the temperature range is -128 °C (-198 °F) to +27 °C (+81 °F). To go for a walk on Mars, you'll wear a Mars walkabout suit that is much like a spacesuit. It provides air, water, and snacks, and maintains a comfortable temperature as you explore Mars on foot. On longer excursions, you'll travel in a rover that provides life support, then don your walkabout suit for adventures outside your vehicle.

Earth & Mars: Elements of the Crust

Earth is made up of three main layers: core, mantle, and crust. We found these Internet sites that describe Earth's structure and have great diagrams:

- Inside the Earth (from This Dynamic Earth, USGS: <http://pubs.usgs.gov/publications/text/inside.html>)
- Earth Structure: <http://zebu.uoregon.edu/~soper/Earth/earthstructure.html>
- Earth's Interior: www.seismo.unr.edu/ftp/pub/louie/class/100/interior.html

Life on Earth lives on and in the outer layer, the crust. The crust and atmosphere contain the nutrients that

make life possible on our beautiful planet (Figures 3 & 4). Mars also has a core, mantle, and crust (Figure 5). For descriptions and images of Mars's structure, go to Composition of the Planets 2 (www.soest.hawaii.edu/PSRdiscoveries/Aug97/InsideMars.html) and Interior of Mars (www.solarviews.com/cap/mars/marsint.htm).

The Martian atmosphere contains carbon dioxide (CO₂), which can be processed to obtain carbon and oxygen. It also contains nitrogen. The north polar cap has water ice, and scientists believe that water exists in the crust in the form of permafrost. The first Martians (i.e., the first humans on Mars) can extract hydrogen and oxygen from water (H₂O).

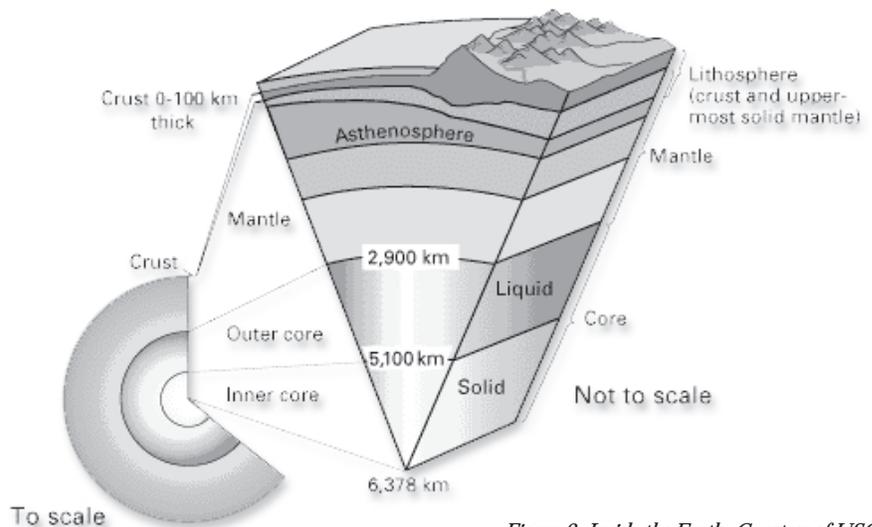


Figure 3. Inside the Earth. Courtesy of USGS.



Figure 4. From Lecture on Earth's Interior, www.seismo.unr.edu/ftp/pub/louie/class100/interior.html. Courtesy of John M. Louie, University of Nevada, Las Vegas.

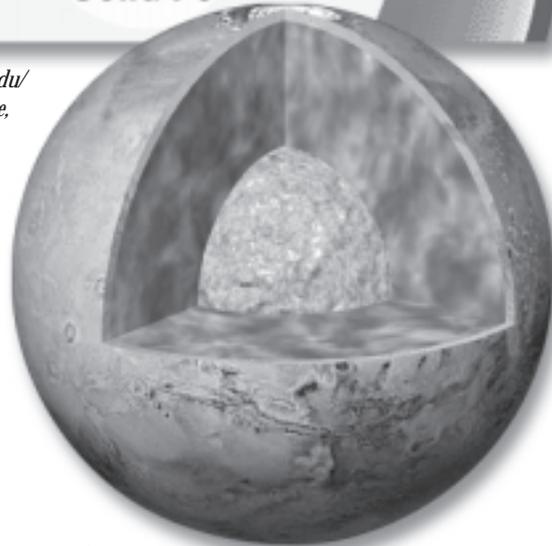


Figure 5. Interior of Mars. Copyright © 1998, Calvin G. Hamilton. All rights reserved.

Plants and animals need much more, and it must be obtained from the Martian soil or brought from Earth. For the long haul, it would be much better to get it locally, on Mars. As Zubrin and Wagner (1997) say,

How fertile is Martian land? It's hard to say, but on the basis of what we know now, Martian soil is likely to prove an excellent medium for crop growth, considerably better than most land on Earth, in fact. (p. 196)

Zubrin and Wagner back up this claim with a table of plant nutrients in the soils of Earth and Mars, which we used as the source of data to compare nutrients in Figure 6. For purposes of comparison, we chose five nutrients (phosphorus, potassium, calcium, mag-

Earth & Mars: Plant Nutrients Compared

Element	Symbol	Earth	Mars
Phosphorus	P	0.06	0.30
Potassium	K	0.83	0.08
Calcium	Ca	1.37	4.10
Magnesium	Mg	0.50	3.60
Sulfur	S	0.07	2.90

Figure 6. Comparison of plant nutrients in the soils of Earth and Mars. Data source: Zubrin and Wagner (1997).

nesium, and sulfur) to show in percentages (%) or parts per million (ppm).

Our plant nutrient data is from chapter 7 of *The Case for Mars* (Zubrin & Wagner, 1997) titled "Building the Base on Mars." This chapter is a cornucopia of information about transforming Martian raw materials into useful resources. You'll learn how to obtain water and oxygen; grow food; generate power; produce ceramics, glasses, metals, and plastics; construct habitats and inflatable domes; and manufacture things you'll need to survive and thrive on the Red Planet.

Reference

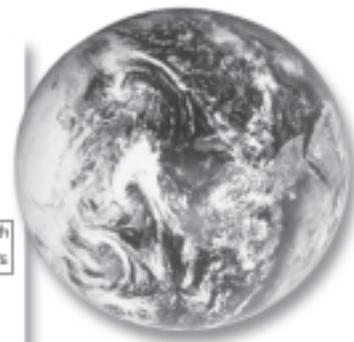
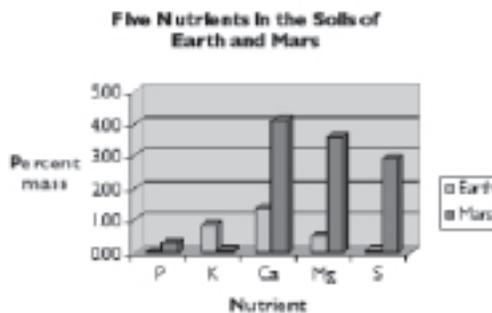
Zubrin, R., & Wagner, R. (1997). *The case for Mars: The plan to settle the red planet and why we must*. New York: Simon & Schuster.



Bob Albrecht (dragonfun@aol.com) is a writer and developer of science, math, and technology curricula. George FireDrake is his alter ego and takes the form of a dragon. Laran Stardrake, whose quotes sometimes lead off this column, is another of Bob's "accomplices." She's half-dragon and half-human. As Laran is fond of saying, "Reality expands to fill the available fantasies." The DragonFun image is from an original painting by Marcy Kier-Hawthorne.



Paul Davis (ctec1@mchs.scs.k12.ca.us) is a mathematics teacher at Maria Carrillo High School in Santa Rosa, California. He was a happy, normal teacher until he met Bob Albrecht and George FireDrake in 1992 and became another one of their accomplices. Since then, Paul has been intertwining math, science, and technology in his classroom with the help of Bob and George.



Elementary, My Dear Watson, Elementary

Our title, "Elemental, my dear Holmes, elemental," is a play on "Elementary, my dear Watson, elementary," which is considered a Sherlock Holmes proverb. However, Holmes never said it in a story or novel, according to *The Proverbial Sherlock Holmes* (www.deproverbio.com/DPjournal/DP,3,1,97/HOLMES.html).

Those who fondly recall the cinematic interpretation of Holmes and Watson by Basil Rathbone (1892–1967) and Nigel Bruce (1895–1953) may be astonished to learn that Doyle's Holmes never uttered the statement most associated with him in the popular mind: "Elementary, my dear Watson, elementary."

The earliest appearance of "Elementary, my dear Watson" is Basil Dean (1888–1978) and Garrett Forts' screenplay of *The Return of Sherlock Holmes* (1929). In the final scene Dr. Watson is there with his "Amazing, Holmes," and Holmes comes forth with his "Elementary, my dear Watson, elementary."

After writing the Holmes and Watson scenario, we woke up in the middle of the night wondering if the phrase "Homo sapiens" was known in 1881. What to do? Toss and turn or look it up. The latter activity prevailed—we leaped out of bed, went to WWWebster Dictionary Search Screen (www.m-w.com/dictionary.htm), entered "Homo sapiens," and discovered that it appeared in 1802. Did we breathe a sigh of relief and return to bed? No, we browsed many dictionaries and found the most interesting stuff. But that's another story for another time.