Fact or Fiction

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Iron

Iron, one of the most familiar elements on earth, is truly one of the "metals of life."[1]

Iron will outlast everything in the universe! According to Carl Sagan, every atom except iron is radioactive, given a long enough period of time.[2] So, it isn't just the radioactive elements such as uranium that spontaneously decay. Even the most stable atoms will radioactively decay, emit alpha and other particles, and then fall to pieces, leaving only iron. The wait would be an interminably long one, however. According to Freeman Dyson of the Institute for Advanced Studies, the half-life of iron is about 10^{500} years. Sagan says if we wait just a little longer, say 10^{600} years, not only would the stars have gone out, but all the matter in the universe that isn't in neutron stars or black holes would have decayed into the ultimate nuclear dust.[2]

Iron is the most abundant metal on our planet, and the fourth-most abundant element in the earth's crust (after oxygen, silicon, and aluminum). It played an important role in the origin of life on an anaerobic, iron-rich earth, and because of this early iron-dependent biochemistry, virtually every life form on earth today depends on this metal.[1]

Yet, there are regions of the planet where iron is so lacking that it is the limiting factor to life. This is especially true of the surface layers of large stretches of the oceans, which are more devoid of life than any desert on land. As Emsley states, "We may think of the seas as teeming with life, but this is true of only a few regions, and these tend to be over-fished as a consequence. More than 80 percent of the boundless ocean is empty."[3]

A recent book, *Iron, Nature's Universal Element*, by Mielczarek and Bertsch,[1] provides fascinating details about iron's role in living organisms, ranging from bacteria and plants to people and other animals. Some of the items they discuss include:

- How humans and other vertebrates rely on the iron atoms in red blood cells to carry oxygen from the lungs to the rest of the body;
- The crucial role iron plays in the growth of common disease-causing microorganisms such as Salmonella and E. coli;
- The mystery of animal migration in birds and other animals, which appears in some cases to be associated with earth's magnetic field; and
- Information on how iron helps fertilize our oceans and soils.

Two of the most fundamental life processes—photosynthesis and nitrogen fixation—depend on iron. In photosynthesis, iron directs the assimilation of the sun's energy. In nitrogen fixation, iron gives leguminous plants, via symbiosis with soil bacteria, the ability to turn the nitrogen in air into amino acids for protein biosynthesis. Together, nitrogen fixation and photosynthesis paint a powerful picture of iron's ability to nourish our planet.[1]

Other roles for iron are in enzymes, for example: those involved in the synthesis of DNA; those that enable cells to release energy by using glucose; and those that scavenge free radicals and protect us. Normal brain function needs iron, which may explain why iron deficiency in infants and children has been associated with slower mental development.[3]

As the Swiss physician, Paracelsus, said, "All things are poison and nothing is without poison. It is only the dose that makes a thing a poison." This certainly applies with iron. Virtually all living organisms walk a tightrope between iron starvation and iron toxicity. Too little iron and cells starve; too much iron and cells are poisoned.[1] Millions of people accumulate toxic iron overloads because of inherited blood diseases, such as thalassemias and hemochromatosis. About one in 10 Americans are symptomless carriers of hemochromatosis, making it one of the most common of the known genetic disorders in the U.S., according to the Centers for Disease Control and Prevention. About one in 200 to one in 400 Americans actually have the disease, characterized by lifelong excessive absorption of iron from the diet. The accumulated iron leads to deadly complications, such as liver cancer and diabetes in adulthood.[4]

High iron levels are an environmental risk factor for atherosclerosis, and this explains why women before menopause are less vulnerable to this problem than men, because menstruation lowers women's iron stores.[5] After menopause, iron levels in women increase, and so does their risk of atherosclerosis.

Platers & Iron

Iron is familiar to most electroplaters, because steel (iron plus small amounts of carbon) is one of our most-often-used substrates. Rust, such as that encountered on steel parts, is also found in the human body.

In 1962, medical reports about Bantu tribes in South Africa provided the first indication that too much iron in the human diet can be toxic. The men of these tribes drank large quantities of homemade beer brewed in iron pots. Because fermentation had leached iron from the pots into the beer, the men ingested so much iron oxide that their livers eventually looked rusty. According to many medical observers, the livers had "rusted away." Rusty liver disease has also been reported in other countries.[1]

When iron levels fall too low, most microbes produce iron-grabbing weapons and battle one another for iron. Their weapons are called *siderophores*. Because siderophores are made by almost all microorganisms, they pervade the living world, including the bodies of humans. Siderophores have one of the most difficult chemical jobs on our planet. Those of us who have tried to remove rust from a piece of metal can appreciate the problem. Siderophores can break down rust and can grab iron from oxides in soil, liquid, or living tissue. Some siderophores do the job better than EDTA, which is used in the finishing industry, as well as to soften water and to treat people with metal poisoning.[1]

Magnetics in Creatures

The ability of migrating birds, sea turtles, whales, salmon, bees, and other creatures to actually sense and orient by iron-generated magnetic fields is a relatively recent finding. The discovery of magnetite (a crystalline form of iron oxide, which is magnetic) crystals in the brains of some birds and fish points to a possible mechanism whereby magnetic effects can be associated with the direction-finding capabilities of some organisms.[1,6]

Honeybees tend to orient their combs, their waggle dances, their resting positions, and their hives with magnetic fields. Their behavior depends on the intensity of the field. By performing a waggle dance on vertically hanging sheets of wax honeycomb, a bee tells its fellow workers the angle between the sun and the food source that the bee has just visited. All of this leads to the conclusion that some animals do indeed have a sixth sense, of which we humans are completely unaware. Thanks to the iron at the core of our planet, some animals virtually "smell" North.[1]

Other Facts About Iron

- The average person loses approximately 1 mg of iron each day in shed skin, urine, and bile. To remain healthy, adults need to maintain 3–4 grams of iron in their bodies at all times. This is enough to provide most adult males and post-menopausal women with roughly 500 mg of iron per liter of blood.[1]
- The average man needs an intake of 10 mg of iron a day, and the average woman 18 mg, but the amount in food is generally sufficient to provide all that is needed.[3]

- Each day, the typical healthy human manufactures 200 billion red blood cells.[1]
- It is postulated that the plague that devastated much of Europe in the mid-14th and 17th centuries struck those who had a diet richer in iron, because most pathogenic bacteria love iron.[7]
- Magnetic forces are assumed to influence health and human performance, so “magnet therapy” has become big business. There is no scientific basis, however, to conclude that small, static magnets can relieve pain or influence the course of any disease. In fact, many of today’s products produce no significant magnetic field at or beneath the skin’s surface.[8]
- Conventional wisdom says that superconductivity and magnetism are incompatible bedfellows. This might not be so, however, in the case of iron.[9] Applying pressure to iron changes its structure from that of a body-centered cubic crystal to hexagonal and close-packed, thereby destroying its ferromagnetic order. In this situation, superconductivity becomes possible. Shimizu, *et al*.[9,10] show that this occurs for iron at a pressure >10 gigapascals (about 100,000 times atmospheric pressure), and at temperatures below 2 K. *P&SF*

References

1. E. Vorburger Mielczarek & S. Bertsch McGrayne, *Iron, Nature’s Universal Element: Why People Need Iron & Animals Make Magnets*, Rutgers University Press (2000).
2. C. Sagan, *Broca’s Brain*, Ballantine Books (1979).
3. J. Emsley, *Molecules at an Exhibition: Portraits of Intriguing Materials in Everyday Life*, Oxford University Press (1998).
4. R. Rubin, “Iron-overload disorder often goes undiagnosed, too,” *USA Today*, 5D (April 2, 2001).
5. P.W. Ewald, *Plague Time: How Stealth Infections Cause Cancer, Heart Disease & Other Deadly Ailments*, The Free Press (2000), p. 120.
6. W. Agosta, *Thieves, Deceivers & Killers: Tales of Chemistry in Nature*, Princeton University Press (2001).
7. R.S. Desowitz, *Who Gave Pinta to the Santa Maria?*, W.W. Norton & Company (1997).
8. S. Barrett, “Magnet Therapy,” Quackwatch (www.quackwatch.com), April 26, 2001.
9. S.S. Saxena & P.B. Littlewood, “Iron Cast in Exotic Role,” *Nature*, **412**, 290 (July 19, 2001).
10. K. Shimizu, *et al.*, *Nature*, **412**, 316 (July 19, 2001).