

Mercury, God of Thieves

Selenium's pivotal role in counterbalancing mercury in environment

By BRAD JONES
GPAA Editor/Content Director

When it comes to the complicated world of biochemistry, world renowned toxicologist Dr. Nicholas Ralston may explain it best when he says mercury is the god of thieves.

"Mercury can cause harm, but not in and of itself. The only way it can cause harm is by robbing your selenium," Ralston said in a recent interview.

"Mercury is named after the Roman god, Mercury, known as the god of thieves. And, what mercury, the element, does inside our bodies is steal our selenium," he said.

Biochemistry blues

"Mercury binds to selenium and that's how it causes toxic effects. When mercury and selenium meet, they form a chemical bond that links them together and mercury will not let the selenium go," he said.

Ralston went on to explain that without selenium, our brains would turn to mush. So, it is clear that our bodies need selenium. In fact, without selenium protecting our brains and our hormone-producing tissues from oxidative damage, we would die. Selenium and sulphur work together to stop oxygen from eating our brains. So, forget what you've been told; in reality what is going to be the death of us is not mercury, but our old friend oxygen — the very air we breathe.

"Mercury can steal your selenium and leave you vulnerable to oxidization, which is corrosion, like rust on metal. You don't want that happening inside your brain," Ralston said.

Selenium provides an enamel, or "anti-rust paint" that coats our brains. It acts as a protective shield against oxidative damage to our brains. However, mercury acts like an abrasive that removes this protective barrier and that lets the dangerous byproducts of normal oxygen metabolism harm our brains. Provided we always have a fresh coat of selenium-dependent enzymes, our brains are protected from oxidative damage just like paint protects metal

against rust.

"Without selenium, our brains would not last very long. What mercury does is steal our selenium and that makes us ill because all the normal functions of selenium are no longer done."

Back to mythology

The element selenium gets its name from Selene, the Greek goddess of the moon. So, to simplify the biochemistry, imagine that Selene has amassed a large army at her fortress to protect us against an attack by Oxygen.

All is well until Mercury, God of Thieves, arrives in battle gear and one by one begins to rob Selene of her sentries. Each of Mercury's soldiers is strong enough to capture one of Selene's soldiers, thus weakening her defenses, but they are too weak to harm Selene herself.

Selene normally has hundreds of times more troops than Mercury, so she usually wins every battle. But, if Mercury's troops were ever to outnumber hers, Selene and the captured sentries would no longer be able to protect us from the real enemy at the gates — our old friend and foe, Oxygen.

Fish and mercury

Ralston's ground-breaking research is beginning to allay fears of eating mercury-contaminated fish and thus the dread of manmade and natural mercury deposits found in our streams, rivers and lakes.

And, fish remain a selenium-rich food source.

"Eating fish doesn't cause mercury toxicity; it prevents it," Ralston said, explaining that fish often have high levels of selenium, much higher than any mercury.

In other words, if there are 20 selenium atoms for every mercury atom present in a fish, ingesting the mercury won't harm you, he said.

"The worst one atom of mercury can do to you is steal one atom of selenium, so with 20 selenium atoms for every atom of mercury you take in you are still 19 selenium atoms to the good. You are actually better protected from mercury than you were before you ate the fish," he said. "If you have been exposed to a high amount of mercury and go to the hospital, your doctor might say, 'Well, quit exposing yourself to mercury!' But, a really smart doctor would say,

Plot AT with DAKOTA
Worked on by EPA study

'And, add some selenium to your diet. Eat some fish because fish are selenium-rich.'"

Fighting mercury with selenium

Not only does the selenium in the fish replace the selenium lost to mercury binding, but recent studies show that increased selenium in our diets will move mercury from our bodies, Ralston said.

When it comes to the environment and high mercury levels found in our streams, rivers and lakes, Ralston contends that rather than going to the huge expense of trying to remove mercury, it would be simpler, cheaper and far more effective to simply improve the availability of natural sources of selenium. In areas that are impacted by high mercury exposures, this would be the best way to remove mercury from the fish and restore their selenium back to healthy levels.

Citing a study in Sweden, Ralston pointed out that fish in certain lakes were deficient in selenium and contained high mercury levels. But, restoring selenium to healthy levels in the lakes caused the mercury levels in the fish to drop by 80 percent in just three years.

"This is being looked at in other areas, but needs to be done very carefully because too much selenium can be dangerous, too. Selenium is a lot like water: Too little will kill you, but so will too much. Fortunately, this approach is well understood now and it appears to be the most effective and least expensive way to deal with mercury in the environment," he said.

Scientific status quo

Understanding the biochemistry of mercury and selenium leaves most people — and even some scientists — scratching their heads, Ralston admits.

To fully grasp the mercury issue, you first need to understand selenium physiology. In other words, anyone who claims to understand mercury and its effect on the environment without mentioning selenium, just doesn't get it.

"It's like having a 16-year-old explain that they know how to balance a checkbook, but can't understand how they could be overdrawn because they still have plenty of checks," Ralston said.

Not only is educating the public about selenium important, but an even greater challenge that may lie ahead is changing longheld opinions about mercury in the scientific community and among environmental groups.

The Society of Toxicologists is slated to discuss the mercury and selenium issue in 2014, but in the meantime, Ralston is doing his best to get the message out to the public.

"The mercury-selenium interaction will be high profile next year. As scientists, we base all our decisions on evidence and the evidence is informing us that some of

our early assumptions are wrong. We need to communicate this to the public and make sure they understand what it means," he said.

When Ralston first started studying mercury toxicity, like everyone else he believed exposure to mercury was harming baby brains in expectant mothers. But it seems fear and widespread media hype may have clouded reason to some extent.

Like others scientists, Ralston wrongly assumed that most fish must contain a lot of mercury and very little selenium. But, he soon found out such was not the case. Through his research, he discovered most fish contained much more selenium than mercury. He began to see how mercury lends itself to toxicity — not by its mere presence, but because it binds with selenium and depletes it from our bodies.

"I got into the mercury issue because I understood selenium physiology, I understand how important selenium is to the brain," he said. "When I learned that the harmful effects from mercury exposures were based on a study where most of the mercury exposure came from mothers eating pilot whale meat, it all made sense. It would be astonishing if eating pilot whale meat wasn't bad for you. It contains huge amounts of mercury, cadmium, PCBs, and other organic contaminants — literally the highest amounts in any food eaten by humans," he said. "Even those studies found that eating fish protected people against mercury toxicity. The small amounts of mercury present in the fish they were eating did not help cause mercury toxicity. But since those fish were the source of most of the selenium in their diets, fish consumption was the reason why the effects that were seen were not far more severe."

Anyone who suggests we should continue to base advice about eating fish on the adverse effects that were observed in children whose mothers were eating whale meat should go back to school, Ralston said.

Eating fish should be encouraged, not discouraged, especially now that we have the results of several bigger and better studies that uniformly show mothers who ate more fish during pregnancy saw great benefits in their children's IQs as well as their social and scholastic skills, Ralston said.

Still, many pregnant women avoid fish in their diets because they fear mercury could harm their babies. Ironically, it appears they are actually doing more harm than good to their children by not eating fish.

And, just to add a little more irony to the mix, Mercury is also the Roman god of science and medicine. Go figure.

Brad Jones is the Editor / Content Director for Gold Prospectors Association of America. He can be reached at bjones@goldprospectors.org

Mercury mines

2nd Article
"Some mercury mines are actually on tributaries that are confluent to the gold-mining areas. So, there are plenty of places in California where mercury in those rivers is not from historical mining," he said. "I talked to a mining friend of mine and in one area he said he could hold his dredging nozzle up to the rock and he could see the balls of mercury just coming out of it."

Greene stressed that elemental mercury is not harmful to humans or animals unless it is inhaled as a vapor in the form of methylmercury.

"Methylmercury is elemental mercury that has been acted upon by bacteria under anaerobic conditions, into an organic form of methylmercury and then amplified," he said. "That's not happening in the rivers. That takes stagnant water and has to be anaerobic (without oxygen) — not water bubbling down the river."

It's elementary

"Mercury is quicksilver at in its elemental form. You can drink it and it will just go straight through your body; it won't do anything to you. The problem with mercury is its vapor. It has to have a route into your lungs and into your brain, kidneys and liver.



symbol Hg and atomic number 80. It is commonly known as hydrargyrum (from Greek *hydr* (water) and *argyros* (silver)). It is a liquid at standard conditions for temperature and pressure. It is the only metal in its liquid state of any metal.

Mercury occurs in deposits throughout the world. The pigment vermilion, a pure form of mercuric sulfide, is mostly obtained by reaction of mercury produced by reduction from cinnabar with sulfur.

You can't do that just by swallowing it. It has to have had some evaporation," Wise said.

"You may use it in a controlled environment. You don't use it out on the river. Most people don't use mercury because they don't understand it," she said. "Methylmercury is the most toxic form of mercury. It attaches to selenium in the brain, kidneys and liver and that causes damage."

Because selenium, which is also naturally occurring, binds with mercury, the body needs more selenium to replace the amounts lost to mercury binding. In simplistic terms, mercury and selenium bind to form mercury selenide and cancel each other out. Mercury (Hg) and selenium (Se) are rarely found in isolation in nature. Most of the time they are found together.

According to Dr. Spencer Peterson, another scientist, the HgSe bond is so strong that only the most powerful acid, *aqua regia*, can dissolve it.

"In other words, once the compound is formed in nature, it becomes biologically unavailable," Peterson states in a recent peer review. "Oh yes, it is found in animal tissue and is actually the protective mechanism that prevents poisoning by either Hg or Se by themselves. They are mutually antagonistic."

Aqua regia is an acid mixture of concentrated hydrochloric and concentrated nitric acid. It is also the only acid that can dissolve gold.

"Methylmercury binds to the selenium in the brain, kidneys and liver, keeping it from performing its important functions in the body. If there is too much mercury present, it binds too much of the selenium and important tissues of the brain become vulnerable to harm. Provided there is enough selenium in one's diet, it can offset the amount lost to mercury binding in the body and keep the brain's selenoenzyme activities operating at optimal levels.

U.S. Geological Survey

According to a United States Geological Survey study, titled *Mercury Contamination from Historical Gold Mining in California*, written by Charles N. Alpers, Michael P. Hunerlach, Jason T. May, and Roger L. Hothemub, total mercury production in California between 1850 and 1981 was more than 220 million pounds and production peaked in the late 1870s. Although

most of this mercury was exported around the Pacific Rim or transported to Nevada and other western states, about 12 percent (26 million pounds) was used for gold recovery in California, mostly in the Sierra Nevada and Klamath-Trinity Mountains.

While both Wise and Greene don't dispute these facts, they do object to the rest of the study which has been used as a springboard for environmental activists to create the misconception that tons of mercury are being dumped into our rivers and streams and that gold prospectors still use mercury to separate gold from black sands.

Oh, the irony of it all

Greene cited another study by Rick Humphreys that shows suction dredging recovers 98 percent of the mercury from rivers and streams. Humphreys used a four-inch Keene dredge provided by the United States Forest Service for the research.

Those results are referenced in the State of California's Final Subsequent Environmental Impact Report on a proposed Suction Dredge Permitting Program, which recognizes that suction dredgers remove more mercury than they discharge from the stream bed.

"According to Humphreys (2005), suction dredges remove 98 percent of the mercury they dredge," the FSEIR states.

More importantly, the report also states "selenium mitigates mercury toxicity; thus, mercury poses no human health or aquatic risk."

Even more ironic, considering the statewide ban on dredging, is the FSEIR acknowledgement that small-scale suction dredge mining cleans mercury from the streams and rivers: "Suction Dredges collect and remove mercury (Hg) and other potentially hazardous materials (e.g. lead) from the stream bed."

So, why aren't environmental activists praising today's miners rather than condemning them?

In fact, several environmental agencies have used suction dredges to remove mercury from rivers, streams and reservoirs and have asked the government for funding to do it, while at the same time condemning gold miners who are removing mercury and lead for free.

Brad Jones is the Editor / Content Director for Gold Prospectors Association of America. He can be reached at bjones@goldprospectors.org

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