The Toxicity of Mercury

The metal mercury is famous for being subtly toxic. When I was in high school and college, it was fun to play with liquid mercury which seemed quite harmless. Some students would coat silver coins with mercury and even swallow drops. It was common for dentists to use a mercury amalgam for filling cavities. These actions are not where the real danger of mercury poisoning arises since our skin and intestinal lining are not very permeable to metallic mercury and dental amalgams tightly bond the mercury within them. Mercury vapor and mercury compounds, however, are quite dangerous.

For years, liquid mercury was regularly used in widely available thermometers, barometers, blood pressure manometers, and fluorescent lights, all made of glass. It was not unusual for one of these devices to break and spill their beautiful shiny liquid mercury onto the floor where it would break into droplets. In spite of efforts to clean up the mess, mercury would fall into cracks in the wooden floor where it would very slowly evaporate into the room over future decades. Occupants of the room would breath this mercury vapor which would enter their blood stream, replace sulfur in some amino acids and disrupt the function of proteins and enzymes made from those amino acids.

Organic mercury compounds like methylmercury, $CH_3\text{-}Hg^+$, ethylmercury, $C_2H_5\text{-}Hg^+$, and especially dimethylmercury, $(CH_3)_2\text{-}Hg$, are very toxic. Methylmercury dumped by a factory into Minamata Bay in Japan from 1932-1968 led the shellfish in the bay ingesting methylmercury and ultimately the Minamata villagers ate the shellfish. As a result, the mercury damaged the nervous systems of over a thousand people with the effect continuing for 40 years after the dumping was halted. A similar, but smaller, disaster happened from methylmercury dumping into the Agano River in northwestern Japan.

Dimethylmercury is much more dangerous. It is a small, non-polar molecule that can quickly pass through normal protective gloves and through the skin. In a shocking case in 1996, a toxicology researcher at Darthmouth College, Prof. Karen Wetterhahn, who was taking all the precautions thought necessary for handling dimethylmercury, accidentally dropped a single drop on her gloved hand. Unknown to her, it passed through the glove and her skin within seconds and began damaging her nervous system. Five months later she started showing symptoms, then lapsed into a coma and was taken off of life support nine months after her exposure.

Mercury passes up the food chain, becoming concentrated as it reaches larger fish-eating fish and finally humans. Our bodies can gradually dispose of methylmercury, and eating fish gives us certain essential fatty acids, but too much of certain kinds of fish can be a problem. The optimum solution is to cease dumping mercury into the environment.

Carrots and Vision

Children are told to eat their carrots so they can see better. This is a plausible story because carrots contain lycopene which our bodies can convert beta-carotene, then to retinol (vitamin A) and finally to retinal, the key light-detecting chemical in our eyes. In fact, however, we get vitamin A from lots of other foods as well.

The source of this story, however, is quite interesting. During World War II as the Germans were bombing England, the English anti-aircraft gunners were quite successful at hitting German airplanes at night because the allies had just invented radar and were using it. To throw the Germans off, the story was put out that our gunners were so good because they ate lots of carrots and had better night vision as a result.

The diagram at the right shows the molecular structures of some key molecules associated with vision in animals. Eating tomatoes, carrots and other colored vegetables give us lycopene which our bodies can convert to beta-carotene and then into retinol, also known as Vitamin A.

Retinol and a closely related chemical, retinal, are used in a cyclic process taking place in the rods and cones of our eyes. That process converts light energy of individual photons into electrical energy to be sent to the brain and experienced as vision.

Many proteins assist in this process as enzymes, but one called rhodopsin is particularly important. A bent form of retinal, 11-cis retinal, is attached to rhodopsin, and upon absorbing a photon changes to the straight form, full-trans retinal. This change induces a change in the rhodopsin that in turn initiates a cascade of molecular changes that ends with a nerve impulse being sent.

All intermediate forms of the molecules are then reset to their original form to be ready for another photon. The chemistry of it is a marvelous process that has only recently been fully understood.