Researchers are looking at several naturally occurring elements and vitamins that may potentially protect against cancer. Despite a somewhat checkered past, selenium, an element obtained through the diet, may have a promising future in cancer prevention.

Selenium is widely distributed in inorganic form in soil and in organic form in certain foods. An excess or a deficiency in selenium intake can cause a variety of clinical symptoms and toxicities in humans. Most people in developed countries receive adequate amounts of selenium in its organic form (selenomethionine) found in cereals, grains, fish, and certain vegetables. Historically, selenium has been classified as a nutrient, but it is classified also as a toxin and a carcinogen. Recently, selenium has been labeled a "chemoprotective agent."

Research in the 1970s showed that selenium binds to and detoxifies poisonous levels of mercury. Mercury and other heavy metals oxidize low-density lipoproteins in the blood, a process that promotes arteriosclerosis and eventually leads to heart disease. Studies have shown that people in Japan with high levels of serum selenium who also eat mercury-tainted fish have a much lower rate of heart disease than the U.S. population.

Research on Canadian Eskimos provides another example of the protective properties of selenium. Éric Dewailly, director of the Environmental Health Service at Quebec's Public Health Center, has studied the Inuit from northern Quebec over the past decade. The Inuit have higher than normal blood levels of lead, mercury, and polychlorinated biphenyls (PCBs), which can be especially toxic to children and fetuses (see Dewailly et al., *EHP* vol. 101, no. 7, p. 618 and a related article, Chan et al., *EHP* vol. 103, no. 7-8, p. 740). Also, the smoking rate among Inuits is approximately 65%, about twice that of southern Canadians. Surprisingly, however, the Inuit have low levels of cancer and heart disease.

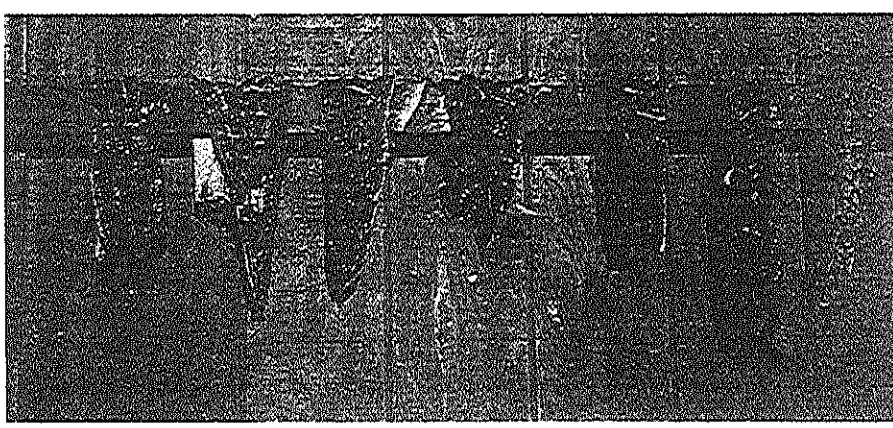
Researchers believe the Inuit may be protected by their intake of such protective substances as selenium and omega-3 oil from their diet of muktuk (skin of beluga whales) and other marine animals. Dewailly explains that "Inuit whole-blood selenium levels are about 10 to 15 times the levels found in the U.S. population." Although this evidence is intriguing, some researchers question whether confounding factors such as a shorter life span may account for the difference in disease rates. Because the average life expectancy for Inuits (62 years) is slightly lower than for the U.S. population, one theory is that Inuits do not live long enough to develop certain cancers. However, because cancer incidences for a population are typically age-adjusted, this may not be a real factor.

Results of epidemiological studies are inconsistent on the protective role of selenium against chemically and virally induced cancers. In a 1993 study published in the *Journal of the National Cancer Institute*, selenium, in combination with vitamin E and beta-carotene, successfully protected against spread of esophageal and stomach cancer in a clinical intervention trial conducted in Linxian, China.

Studies in laboratory animals also support the protective role of selenium in cancer. Rat, mouse, and hamster models have been used to study liver, breast, colon, skin, and pancreatic cancers. A review titled "The Chemoprotective Role of Selenium in Carcinogenesis," published in the *Journal of the American College of Toxicology* in 1986, stated: "Of 35 studies published since 1949, 31 have shown that selenium produced an inhibitory response, whereas only 3 reports have found that there was no effect." The review continued, however, "In 1 case, selenium . . . increased pancreatic ductular carcinoma yields," indicating there is still no clear-cut case for selenium's protective role.

Most of these animal studies have used the inorganic form of selenium (selenite, selenate, or selenium dioxide). The primary concern with these compounds is that they may be toxic at doses required to achieve chemoprotection. To address this problem, Karam El-Bayoumy, associate division chief at the American Health Foundation, and his colleagues are attempting to develop novel synthetic organoselenium compounds that are chemoprotective and have low toxicity.

Results of several studies published in a review article in the November 1994 issue of *Carcinogenesis* show that one promising organoselenium compound from El-Bayoumy's laboratory has reduced tumors in breast, lung, and colon cancer in animals caused by several different carcinogenic agents, including one present in tobacco smoke. Requests to conduct detailed toxicology testing are now being accepted by the National Cancer Institute. Following this testing, the compound may enter phase I clinical trials, although no timetable can yet be estimated.



Laurie Chan/CINE

Fish tales. Traditional seafood diets may protect against environmentally related diseases.

Computer Recycling Takes Hold

Old computers never die, they just go to the attic . . . or the basement, or the local elementary school. At least, that's where they've gone until now. But the likelihood that outdated computers will start ending up in landfills is increasingly high. According to scientists at Carnegie-Mellon University, the average computer now becomes obsolete within 12 months of production. They predict that about 150 million personal computers will be in landfills around the world by the year 2001—enough to fill an acre-wide hole three-and-a-half miles deep.

"Today, two computers become obsolete for every three purchased," D. Navin-Chandra, an assistant professor at Carnegie-Mellon, recently told *Fortune* magazine. "By 2005, the ratio will be 1 to 1, which means we should be able to recycle computers as fast as we make them."

The lack of a recycling infrastructure for computers poses a threat not only to municipalities faced with collecting and disposing of the computers in their landfills, but also for the manufacturers, who might be held responsible for any leakage of toxic materials from these computers. Some computers have leachable quantities of lead and other toxic materials, although they are present only in small quantities.

Computers have at least some components that are economical to recycle. Specialty recyclers like the Handy and Harman company have been involved in the disassembly and recovery of materials from computers, printers, and other electronic hardware since the early 1960s. Their business is growing at the rate of 15–20% a year.

"The principal economics with a computer is in the recovery and refurbishment of the subsystems—the hard drive, the keyboard, and occasionally the monitor," says Steven Foulk, marketing executive with Handy and Harman. "The next level involves recovery of the integrated circuits and various components including the processor and memory. The final level is the recovery of precious metals including gold and copper."

Once a computer is more than 4–5 years old, Foulk says, the subsystems are generally not worth refurbishing. At that point, the value comes in "mining" the computer for its raw materials. The typical desktop computer contains about $50 worth of usable material. This includes aluminum valued at $9.37, gold at $6.45, and copper at $5.56. Unfortunately, the costs of collection, dismantling, purification, and smelting can run $45–47 per unit, making it little more than a break-even operation. Plastics, which at $12.07 per unit have the highest value of all components, present a particular problem.

"There are too many different kinds of plastics being used in most computers, which makes them difficult to separate," says Foulk. "Maybe 20 percent is recyclable, and the rest is either incinerated or landfilled."

Responding to pleas from recyclers and environmentalists, computer manufacturers are beginning to design their products with end-of-life management in mind. Two schools of design are emerging: design for the environment (DFE) and design for disassembly (DFD). IBM's Engineering Center for Environmentally Conscious Products is pioneering advances in both these fields.

"Starting in 1991, we emphasized design that used fewer materials and less energy," says J. Ray Kirby, director of the IBM center. "Within the second year, we focused on how to design to assist in recovery and recycling. Our PS/2E qualifies for the government's Energy Star Logo. It tak7es less energy to run than most PCs and the plastic cover has 25 percent recycled content."

IBM has only a limited take-back program. The company operates a number of collection centers in Europe, which has a more aggressive stance on take-back. Computers are sent to Scotland where the keyboards are melted down and remolded. In the United States, IBM is piloting some programs to evaluate the costs of take-back, but these are not yet available to all customers.

Joseph Tart

Will not compute. Rather than shelving the problem of what to do with outdated computer equipment, several companies are pushing for recycling and reuse.

Hewlett-Packard operates product recovery centers in Roseville, California, and Grenoble, France, which together retrieve nearly 800,000 pounds of computer and related equipment each month. Products are disassembled and sorted into types of components. Reusable and resalable parts, such as computer chips, are recovered and refurbished. The remaining parts are recycled to the maximum extent possible.

Apple sponsors periodic trade-in programs for its personal-use computers through colleges and universities. Students can receive a $250 discount on a new Apple computer or printer when trading in an older model. Computers are sent to Fox Electronics in San Jose, California, which recovers the integrated circuits and sends other components to other recycling firms. Apple's most recent buy-back program netted over 15,000 computers.

Recyclers identify four major problems that must be addressed if computer recycling is to make significant inroads. First, computers need to be designed for easier disassembly, which currently runs about $20 per desktop computer in labor costs alone. Second, separation systems for mixed plastics need to be developed. Third, recycling efficiency for metals needs to be improved. And finally, recycling processes need to be developed for elements, particularly exotic elements such as rhodium and terbium, which are not currently being recycled, but which may become critical because rare elements are used in advanced computing systems.

"For recycling to be effective, the infrastructure to take computers apart has to be as big as the manufacture," says Foulk. "The infrastructure for recovery of the metals is in place. The infrastructure for dismantling and recovering subsystems that still have value is developing. Collection and transportation is in its infancy."

Measuring UV's Effects

Long-term exposure to UV-B rays, the spectrum of sunlight with a wavelength shorter than 320 nanometers, is known to contribute to a variety of human ailments including premature aging of the skin, non-melanoma skin cancer, and cataracts. It is also suspected to play a role in melanoma skin cancer and suppression of the immune system. Stratospheric ozone is the most important factor determining the amount of UV-B radiation reaching the earth's surface. Concern about human exposure to UV-B has been increasing since decreases in atmospheric ozone were discovered over Antarctica in 1985. Unfortunately, there is no worldwide network for measuring changes in UV radiation, so there is no clear understanding of how much UV radiation is increasing in different locales, or whether such increases might be responsible for observed changes in biota. But that situation is about to change.

In coordination with the U.S. Global Change Research Program, the EPA has