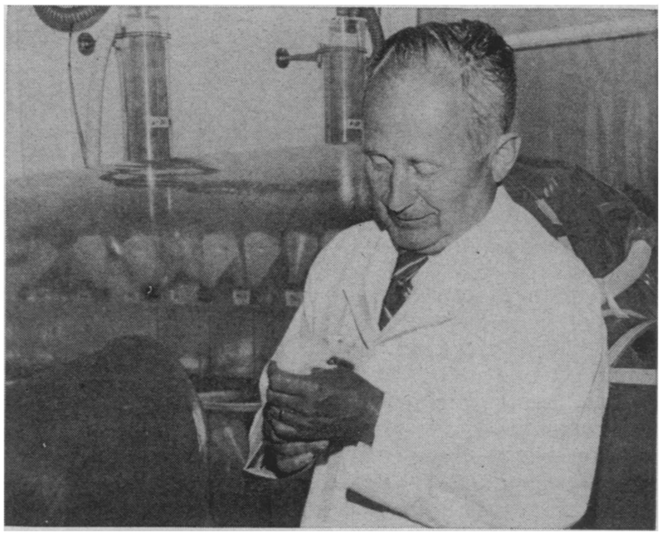


VA Hospital, Long Beach

Trace-element researcher Schwarz in his special lab.

Trace elements: No longer good vs. bad

by Joan Lynn Arehart

Back in the mythical age of innocence, so the story goes, the elements in the thin skin of matter on and just above the earth's surface swirled around and moved up and down, yet managed to maintain a delicate equilibrium. Soils and foods abounded with the necessary dietary elements. Compounds passed from air to earth to plants to animals, and back again. Then, with the arrival of industrialization, man seemed to upset the natural course of elemental events. Factories spewed contaminants into the air, soil and water. Foods were steamed, chilled, skimmed, bleached and filtered, possibly losing valuable micronutrients and adding certain other trace elements that were undesirable. Some people chucked varied, well-balanced meals for refined carbohydrates and fad foods. The handwriting was on the wall for scientists concerned with human nutrition and the environment.

There are now promising signs that the situation is getting better, thanks to accelerated research on trace elements. There were only a dozen or so trace-element laboratories in the United States in 1966, Dr. James Smith, chief of trace-element research at the Washington, D.C., Veterans Administration Hospital, estimates. Today there are 50. Work is also taking place in various European countries, the Soviet Union, Australia, Iran and Egypt.

One noted realization in the trace-element field has been that more trace elements are essential to the diet, or possibly so, than previously thought. Only seven trace elements had been found to be essential in one or more animal species by 1953. Four have since been added—three by Dr. Klaus Schwarz of the Veterans Administration Hospital, Long Beach, Calif., and one by Drs. Schwarz and Walter Mertz of the U.S. Department of Agriculture in Beltsville, Md. The essential elements are iron, iodine, copper, manganese, zinc, cobalt, molybdenum, selenium, chromium, tin and vanadium. Others, such as nickel, also show promise for certain species. Dr. Schwarz expects within the next six months to show that two more trace elements are necessary.

Finding that trace elements previously considered toxic are now essential jeopardizes the classic pigeonholing of elements as either good or bad. Selenium, long considered a poison, particularly in livestock (thousands of animals were lost on the American Great Plains from eating plants grown in seleniferous soil), has now been found to be a dietary essential for livestock. Several selenium deficiency diseases, such as one type of muscular distrophy, have been detected in sheep, swine and poultry in areas where there is little selenium in the soil. Some thorny questions thus are raised. What concentrations of selenium must be present in the soil in order to poison livestock? Because of the dual toxic-nutritional characteristics of selenium, should it be used to fortify livestock feed? If so, might toxic selenium residues slowly build up in livestock, and be passed on to humans when the meat is consumed? It is known that milk cows can transmit some of their dietary selenium to humans in milk. Another case in point is arsenic, with a long and venerable reputation as *the* poison to do someone in with. It has now been shown to produce beneficial effects in some animals.

As Dr. E. J. Underwood of the University of Western Australia points out, some 20 to 30 trace elements that do not meet the exacting requirements for dietary essentials occur more or less constantly in highly variable concentrations in living tissues. They include aluminum, antimony, mercury, cadmium, lead, silver and gold. The presence of these elements in living organisms, Dr. Underwood says, may reflect environmental contamination, or simply contact of organisms with their environment. So another pressing question arises: How does one distinguish between elements which are contaminants and those which are present through natural environmental contact? Dr. Smith thinks the current hoopla over environmental pollution is exaggerated. "Just because we can detect trace elements in tissue now in parts per million or per billion," he says, "does not mean such quantities are necessarily dangerous to health." Dr.

Schwarz concurs, "I am with him on that! I am all for cleaning up the environment where needed, but some mistakes are being made." Dr. Mertz, however, believes that much of the current concern over environmental contamination is based on sound scientific evidence—monitoring of various elements in the blood levels of certain populations and animal studies showing that certain levels of elements lead to disease or death.

Nor do researchers agree on whether environmental "pollutants" might possibly provide some of the trace-element requirements of man. Although elements do not normally enter the lungs, with the possible exception of iodine (reported recently by Dr. Robert Vought of the National Institute of Arthritis and Metabolic Diseases), some scientists do not rule out the possibility that breathing might be a mode of essential trace-element absorption.

To solve classification problems raised by recent trace-element discoveries, Dr. Mertz suggests that scientists refer to toxic and beneficial levels of various elements in atmosphere, soil, food and tissue, rather than label certain elements "beneficial" and other elements "toxic." This is particularly important since the safety margin between toxic and beneficial levels varies drastically from element to element, and also from compound to compound for an element. The USDA trace-element labs in both Beltsville and Grand Forks, N.D., will soon use whole-body radioisotope counting techniques, as well as stable isotopic tracers and neutron activation, to evaluate the availability to man of trace elements in food. "We should eventually get to the point," Dr. Mertz says, "where we can routinely monitor populations for both beneficial and toxic levels of various elements."

An expanding list of essential trace elements, Dr. Harold Samdstead, director of the USDA trace-element lab in Grand Forks, reports, also calls for setting trace-element requirements in man. The information is needed for enrichment of processed foods as well as for manufacture of entirely new foods that may have an increased role in human nutrition in the future. Arriving at a recommended dietary allowance for elements is no easy task, though. RDAs have been published by the National Research Council's Food and Nutrition Board for only a handful of trace elements. The USDA labs are working on RDAs for chromium and zinc.

Finding more dietary essentials and possible essentials also opens new possibilities in using trace elements in medical diagnosis and treatment. However, such use is in its infancy, compared with use of vitamins. One example of recent progress makes use of the observation that unusually high amounts of copper in infants' fingernails are linked with cystic fibrosis. Hence Drs. Richard Wainerdi of Texas A&M University and Guyon Harrison of the Baylor College of Medicine in Houston have teamed up to develop a means of diagnosing copper levels in the fingernails of newborns. They hope their technique will eventually be used for mass screening of newborns for cystic fibrosis.

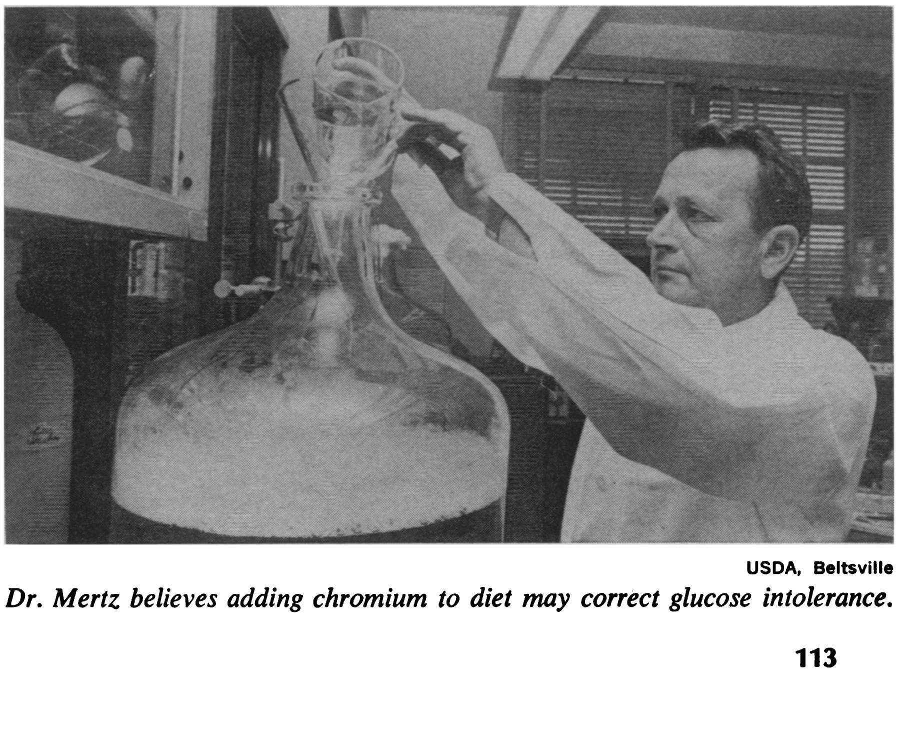
Dr. Mertz foresees using chromium to correct glucose intolerance in older people. Chromium is the active ingredient in a chemical material that Dr. Mertz calls the "glucose tolerance factor," a substance required by the body for proper use of glucose. Dr. Mertz believes that decline in glucose efficiency with age may be related to a decline of chromium in tissue, and that chromium supplements might restore normal carbohydrate use. His team is trying to isolate large enough amounts of the glucose tolerance factor to use on human subjects.

Zeroing in the biological roles of various trace elements has likewise led to closer scrutiny of their functions at the cell and molecular level. Evidence suggests that the essential trace elements, like vitamins, participate in various enzymatic actions. A trace metal may stick onto an enzyme like a sidekick and alter its structure, for example, or it may help carry glucose through the cell membrane. Dr. Benjamin Volcani of the Scripps Institution of Oceanography in La Jolla is studying a marine organism's use of silicon (from sand) to make a silica shell. He believes the process might illuminate how mammals turn calcium into bones and teeth. Dr. Volcani has also found that silicon helps diatoms make proteins, carbohydrates and fats, and that diatoms are unable to synthesize DNA without silicon. It stands to reason, Dr. Volcani says, that silicon may be needed by higher organisms as well. Silicon is still another element which, until several years ago, was believed to be unimportant to living organisms.

Yet that silicon might be essential to some organisms isn't surprising, when one considers that the element is far more common in the earth than carbon, one of the major components of organic compounds, and is below carbon in the atomic periodic table. This brings up another question: Does an element's position in the table explain its biological effectiveness or toxicity?

The basic elements of living matter—carbon, oxygen, nitrogen, hydrogen, phosphorus and sulfur—are all of low atomic weight. Most of the essential trace elements (transition metals) are of middle atomic weight. Because they have similar valence states and oxidation potentials with cell compounds, Drs. Schwarz and Samdstead explain, it is possible that other elements in the transition-metal series may also be found to be essential trace elements. Although none of the heavier elements have been found vital to living organisms, Dr. Schwarz says that some of them may eventually be found to be so.

Dr. Mertz, however, does not believe the atomic periodic table offers much of a scientific guideline to the trace elements' effectiveness or toxicity, which he believes are better determined by the amounts of an element given to a particular organism. What the specialists on trace elements do generally agree on, though, is that more trace elements await discovery as dietary essentials, in various animal species and possibly in man as well. But as Dr. Schwarz points out, since 11 elements are highly radioactive, and 6 are chemically inert, probably not all the elements will be found to be dietary essentials. □



USDA, Beltsville

Dr. Mertz believes adding chromium to diet may correct glucose intolerance.