A Bushel, A Peck, and A Picogram

Remember in chemistry lab how we'd mix a gallon of this and a shovelful of that into a tubful of the other? Perhaps not, but the refinements that have been made in today's scientific research make our bygone student efforts seem to have been that crude. You see, an amazing new scientist has developed in the past generation — the trace substance scientists. They can be found all across the campus, although their concentration probably is heaviest in the College of Agriculture.

What is a trace substance? Explains Dr. Delbert D. Hemphill, professor of horticulture and program project leader for the University of Missouri Environmental Health Center, "A trace substance is anything which you have to work with in nanogram quantities." And a nanogram is a billionth of a gram.

It's hard to believe that anyone can measure anything that small. But the nanogram isn't the tiniest measurement for these researchers. Below that is the picogram. It's a thousandth of a nanogram. Thus, a picogram is a trillionth of a gram, a 30-trillionth part of an ounce, or roughly two quadrillionths of a pound.

Scientists often refer to the concentration of a trace substance in terms of parts per million (ppm). MU scientists can detect some substances even when the concentration is as low as one part in 500 million.

Imagine one truck in a bumper-to-bumper string of cars filling a four-lane highway from Chicago to Denver by way of Columbia. That represents one part per million. One part in 500 million? There are not 500 million people in all the western hemisphere.

A trace substance doesn't stick out like a truck in a group of cars, however. Instead, it is thoroughly dispersed, just as the flavor is mixed throughout a cake. At the same time, its presence is often no more obvious than the traces of iron, copper, or zinc in your body.

Some trace substances are essential to life. Others are subtle poisons. And even beneficial elements can become poisonous as the quantities increase.

Consider our water supply. It can contain both beneficial traces (chlorine and others) and potentially dangerous ones. Dr. Walter D. Keller of Geology and Dr. George E. Smith, director of the Water Resources Research Center, studied samples from Missouri wells. More than a third of them contained above five ppm of nitrogen in nitrate form. Five ppm is considered to be the maximum safe level. Higher levels bring the hazard of "blue babies."

A recognized authority on trace substance analysis, Dr. Edward E. Pickett uses four different methods to detect minute substances. Among them is flame emission spectoscopy.

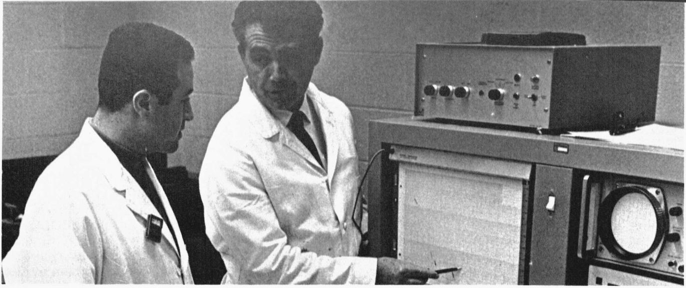
This is one part of the University's study of our health in relation to trace substances in our environment. Another is a state-wide look into birth defects in human infants, domestic animals, pets, and wildlife. This involves a large cross-section of University personnel — from the School of Medicine to the local extension center. Dr. Carl J. Marienfeld and others suspect that trace-amount substances may be responsible for some, if not all of the environmentally-caused birth defects.

Some of the most important work relating trace quantities of zinc and copper to nutrition and health has been done on the Columbia campus by Dr. Boyd O'Dell of Agricultural Chemistry in cooperation with Dr. J. E. Savage, of Poultry. O'Dell's work and that of his colleagues have shown the need for trace minerals in livestock and saved producers untold millions of dollars.

And, although world scientists had long thought that man would never fall short of necessary zinc as long as he maintained a normal diet, O'Dell again led the way. He showed that under certain conditions the zinc in food may be unavailable, causing a person to suffer from zinc deficiency.

Trace amounts of zinc also figure prominently in the work of Dr. John H. Henzel of the School of Medicine. With researchers from other states, he has shown how metal ions in trace quantities can bring dramatic improvement in the healing of wounds. In some instances long-open wounds responded to zinc and quickly began to heal.

A baby who chews lead-base paint from his crib often needs prompt attention to save his life. Diagnosis of lead poisoning once depended on analysis that took days. Now it can be done in the College of Agriculture spectrographic laboratory in a matter of minutes.



Dr. George W. Leddicotte developed many analysis techniques now used world-wide. At left is radio-chemist Odel Abu-Samra.

The need for trace elements in the production of healthy and abundant crops has been brought to the attention of farmers through the work of Dr. William A. Albrecht and other agronomists. Albrecht was a pioneer in soil trace substance work 30 years ago.

Even diabetes catches the trace analyst's curious eye. Drs. James N. Burkeholder and Richard A. Guthrie in Pediatrics are demonstrating the importance of chromium traces in the treatment of diabetes.

Hemphill and others are checking on the pesticides that may enter our bodies in trace amounts. And there may be special problems when corn rootworms take up trace amounts of insecticide and convert them into other compounds, some more toxic, and some less toxic than the original. Dr. Charles Knowles of entomology is studying that action.

Other entomologists, working at the USDA lab on the campus, are mixing small amounts of tracers with the feed for certain insects. These amounts get divided in the female's body when eggs are formed and some goes into each egg. Trace substance detection methods help the entomologists find the freshly-deposited eggs and learn the insects' ways of distributing and hiding eggs.

Trace substance work has applications in space exploration, too. Dr. Charles W. Gehrke, supervisor of the agricultural chemistry laboratories, is so widely respected for his analytical work that he has been selected to analyze the first samples to be returned from the moon. He'll be looking for biologically important molecules — that is, for signs of life.

Because of our University-wide strength in trace substance work, we can do far more than a similar number of individual researchers could do on their own, says Marienfeld. With this strength in mind, the Environmental Health Center sponsored the "University of Missouri's First Annual Conference on Trace Substances in Environmental Health" in Columbia last July.

One after another, world leaders in this field remarked on the interdepartmental cooperation and communication in Missouri. "Workers from out of state were amazed at the excellent communication between M.D., D.V.M., chemist, biologist, and others at MU," explains Dr. Hemphill.

In his concluding remarks to the conference, Dr. William H. Strain of the University of Rochester School of Medicine and Dentistry declared, "The cooperation at Missouri of distinguished investigators working in the varied areas ranging from air, water, and soil to (even) the autopsy table is enviable."

With an eye to the future the Environmental Health Center under the leadership of Marienfeld is developing a proposal for a trace analysis center. It would be a substantial facility, using all of the latest detection methods, each with its own advantages. The most recent and important tool for trace substance analysis is Research Park's 10 megawatt nuclear reactor, one of the largest on any college campus. Its activation analysis laboratory can rapidly perform large numbers of trace substance analyses at one time.

Says Hemphill, "We have a strong base for a staff for the trace analysis center. It could put us ahead of all others in some aspects of this work and provide accuracy and refinement as good as anywhere in the world."

There are four groups of people involved with trace substances at Missouri: (1) scientists doing original research on detection techniques and providing analytical services to other researchers; (2) scientists doing original research on the trace substances and the ways they affect other materials and organisms; (3) scientists doing original research on non-trace-subtance projects but using trace substances

A visiting professor from New Mexico University, Manuel Navarrete is an expert on trace substances in water, plant material.

in some way; and (4) A wide range of individuals who are not in research but are doing work that involves trace substances.

In group one we find Dr. Edward E. Pickett, a recognized authority on trace substance analysis and supervisor of the spectrographic lab. He and his colleague, Dr. S. R. Koirtyohann, use four methods of trace substance detection and have modified almost all of their instruments for never-before-achieved levels of sensitivity. The methods are flame emission and flame absorption spectroscopy, conventional arc spectroscopy, and infra-red or ultra-violet absorption spectroscopy.

Dr. Walter A. Aue and Gehrke, also of Ag Chemistry, do their detection with gas chromatographs and automated analytical systems. They, too, have made modifications to achieve previously unreached sensitivity, and have developed selective and hypersensitive methods for detecting and measuring nitrogen and phosphorus.

In the Research Reactor facility, Professor George W. Leddicotte of Nuclear Engineering and Radiological Sciences uses neutron activation analysis to detect trace substances. He has developed many of the activation analysis techniques that are being used all over the world today.

In chemistry, Dr. John C. Guyon measures trace substances with a fluorescence technique which he is refining. He measures the amount of energy released by a trace substance subjected to radiation. He also works with flame spectroscopy.

The second group, those who study trace substances and their effects, includes more than 50 researchers in varied fields. Trace substance research has quietly become campus-wide in scope.

In the third group we find the researchers who use trace substances as a tool in their work. Typical of this group are Dr. Harold B. Hedrick of Food Science/Nutrition and Drs. Granville B. Thompson and Rodney L. Preston of Animal Husbandry. They use the Low Level Radiation Lab to measure amounts of potassium-40 in meat. This naturally-occurring isotope is found in trace amounts in all living systems. These researchers hope to develop a simple carcass rating system based on the potassium-40 reading.

In the fourth group are doctors at the Medical Center and in Veterinary Medicine who regularly face situations involving trace substances. Also plant pathologists, engineers, livestock men, nutritionists, are among a large portion of the faculty who must be able to recognize, plan for, or contend with the effects of trace substances in their daily work.

Does this volume of trace substance activity represent an overnight change in science, a vastly different approach to research, or a science-fiction writer's dream of Lilliputian miniaturization gone out of control? None of these, say our trace substance workers.

"There have been significant advances in instruments used in this type of work," points out Dr. R. A. Bloomfield, chairman of Ag Chemistry. "This explains a part of the increase, but it has been gradual, not sudden." Another part of the explanation is in scientists' natural reticence toward publicity. Our trace substance workers are not inclined to blow horns or thump tubs. The work has been going on, but they just don't brag about it. They leave that up to us — *By Bob Jones* □

Bob Jones, author of the above article, is science writer in the Agricultural Editor's Office. A native of Kansas, he came to Columbia in 1967 by way of Wisconsin where he worked for several years on trade and company magazines.