spectra in the Perkin-Elmer system, or 4800 in the Beckman instrument, to provide either a precise or a tentative identification of the compound. Other spectral manipulations can also be performed, and accuracy of identification can be improved by using a larger library on more disks. In a sense, what the companies have done is taken a degree of experience and training in spectral interpretation that might exist in only a dozen scientists throughout the world, distilled it into a software package, and made it available to every laboratory in the country. This could have been done before, of course; but even as recently as 5 years ago, according to one Beckman spokesman, it would have required a computer the size of an IBM 370 and would probably have cost at least $200,000. The Microlab 620 MX and software, in contrast, sell for $23,000.

Several other new instruments also demonstrate this trend. The Beckman Toxsys system and the Baird Fluorocomp total luminescence spectrometer incorporate floppy disk memory systems and sophisticated software packages. So, too, do the DuPont 1090 thermal analysis system, the Cromatix GPC Lab Data System, the Spectra-Physics SP 4000 data system, the Princeton Applied Research model 384 polarographic analyzer, and the Bascom-Turner 8110 Intelligent Recorder. In varying degrees, each of these is designed to provide answers rather than spectra.

Here, too, there may be a one-time effect on sales growth. Some analysts attribute much of the recent growth in sales to the increased prices associated with incorporation of electronics hardware and software. When this round of incorporation is complete, they predict, sales will show a lower, more realistic growth rate.

The combination of rapidly accelerating technology and increasing prices is producing some unusual ripple effects among instrument users. A few laboratory heads, for example, have indicated a desire to lease rather than purchase expensive instruments right now because they fear that much more advanced models will be available in the near future. This attitude is noticed most commonly in those areas where the link between instrument and computer is not complete. Manufacturers, however, contend that they have seen little evidence of such reluctance. One manufacturer's representative, more cynical than the rest, even suggested that new instruments are only good for a couple of years anyway. Instrument leasing has increased somewhat recently, notes a Varian executive, but it still accounts for only a miniscule share of the market—certainly less than 2 percent. Instrument salesmen are attempting to overcome some of this real or perceived reluctance by offering liberal trade-in allowances for used instruments. Unlike the automobile industry, however, the majority of the trade-ins are simply junked.

The accelerating technology creates problems in a competitive academic environment because instruments must be replaced faster to combat obsolescence, whatever the cost. This necessity may alter the competitive balance among university chemistry departments. The National Science Foundation (NSF), which provides the bulk of funding for instruments in such departments, has traditionally restricted its grants to limit each department to one purchase per year. Faculties of the better schools have recently pointed out, though, that this policy and others have resulted in a slow but steady erosion of their research capabilities. NSF officials have reluctantly agreed with their contention and, beginning this year, will allow more than one award to be made to any department when a strong case can be made. Since the amount of funds available has not increased significantly, however, the practical result of this policy may be that chemistry departments in the lower echelon schools must either find new sources of instrument funding or fall by the wayside.

A final trend involves the instruments themselves. The increased simplicity of operation of instruments has frequently been accompanied by an increased difficulty of repair and maintenance. Many scientists within a department, furthermore, are frequently not aware of the capabilities of new instrumentation. Some universities, therefore, are hiring new faculty members to be in charge of all instrumentation and to assist their fellow scientists in using them to their fullest capacities; these specialists are often in charge of shops, also. The new faculty members are often accompanied by highly trained technical personnel responsible for maintenance and repair of the instruments; in many cases, these technicians receive higher salaries than full faculty members. Total budgets for operation of instruments for one department may approach $1 million per year. A few examples of such faculty members and schools where the program is working include John Amy of Purdue University, Charles Wilkins of the University of Nebraska, Frank Anet of the University of California at Los Angeles, and Paul Bender at the University of Wisconsin. As the complexity and sophistication of instruments continues to grow, such faculty may become commonplace, putting further strains on already tight departmental budgets.

—THOMAS H. MAUGH II

Toxicology: New Laws Mean New Instruments

The primary response of the analytical instrument industry to the increased testing mandated by new environmental regulations has so far been refinement and adaptation of existing instruments. It would be very surprising, however, if there are not a number of new instruments and systems introduced in the future to meet the needs addressed by that legislation. One harbinger of such a development is Beckman Instruments' introduction at the Pittsburgh Conference of two new systems for toxicology testing. Both are designed to simplify testing and to ensure more reliable and reproducible results.

The first system, called Microtox, is designed for monitoring the acute toxicity of waste waters, industrial effluents, and the like. Current federal regulations require that many industrial discharges be tested with fish, daphnia, or other aquatic organisms to determine whether toxic chemicals are being released; this testing is most often performed with fish. In theory, the procedure requires exposing a certain number of fish to the effluent or toxicant for 96 hours. The toxicity is then expressed as an LC_{50}, the concentration that is lethal to 50 percent of the organisms. In practice, the procedure is much more complex because the fish must be acclimatized to the laboratory for 10 to 30 days prior to the testing, trial dilutions of the toxicant or effluent are necessary to determine the best concentration for accurate results, and great care must be taken to ensure that the highly sensitive fish are not affected by external factors. Results obtained in this fashion, furthermore, are somewhat limited, both be-

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The Toxsys data station is contained on a cart that can be rolled from one laboratory to another. The keyboard is mounted in a drawer so that it can be stored when not in use.

cause the number of organisms is limited and because the test detects only lethality. The cost per test is generally at least $300 and can be more than $1000.

The key to development of the Microtox system, according to Don L. Isenberg of Beckman, was to find an organism that is suitable for study in large numbers to give reproducible results, that provides a readily measurable response to toxicants, and that can be stored easily until it is needed. Isenberg and his colleagues finally settled on a strain of luminescent bacteria known as *Photobacterium fischeri*. These organisms can be freeze-dried and stored in a refrigerator for as long as a year before a sample is reconstituted for use, and are small enough so that about 100,000 cells can be examined in a small cuvette. Most important, the bacteria are highly sensitive to toxicants, and the decrease in emission of light is linearly related to the concentration of the toxicant.

With the bacteria in hand, it then became a relatively simple matter to develop a small unit to incubate the cuvettes and to measure light emission. Emission is measured both before and after addition of toxicant, and electronics in the instrument calculate and display the percentage decrease in light emission. Toxicity is expressed as the effective concentration, EC_{50}, at which light emission is reduced by 50 percent. An individual measurement takes less than 5 minutes, and a complete analysis can be performed with a sample volume as low as 10 milliliters. The cost per analysis, Isenberg says, is at least two orders of magnitude lower than that of the fish test.

For the Microtox system to be accepted by regulatory agencies as an alternative to fish tests, it must be shown that results of the assays are comparable. Preliminary findings at Beckman and at several laboratories working with prototype instruments, Isenberg says, suggest that this is the case. This conclusion is echoed by William Peltier of the Environmental Protection Agency Research Laboratory in Athens, Georgia; he is using one of the prototypes to monitor industrial effluents. He cautions, though, that it will be necessary to build up a much larger data base before it will be possible to say with assurance that Microtox is as good as fish tests. He also notes some potential problems. Perhaps the most important of these is that analysis of an effluent stream with Microtox generally is done by spot sampling or by preparation of a composite sample, whereas fish can be exposed to the effluent stream continuously. If high concentrations of toxicants are released intermittently, they may be missed by the spot sampling or diluted so much in the composite sample that they are not detected; fish would still display the lethal effect. Such problems can probably be solved, however, and Peltier concludes that Microtox can be a "useful tool."

The second new product, called Toxsys, is an automated data-gathering and reporting system for toxicologists and pathologists conducting bioassays. A typical carcinogenesis assay conducted under the Good Laboratory Practice guidelines issued by the Food and Drug Administration last December, for example, will produce some 5 million digits of data over a 2-year period; that data must be handled in a very structured manner. Careless handling of just a small amount of the data can render an entire project meaningless at a cost of at least $250,000 and, more important, 2 to 3 years worth of work. Several studies conducted in industrial testing laboratories have already been rejected by government agencies because of sloppy handling of data and animals. The Toxsys system is designed to provide maximum assurance of the integrity of data by reducing or eliminating manual transcription of data.

The heart of the Toxsys system is a microprocessor and two floppy disk memory units mounted on a laboratory cart. Attached to this are a cathode-ray tube (CRT) overlaid with a transparent, touch-sensitive panel, an electronic scale, a bar code reader similar to the optical scanning readers used in supermarkets and department stores, a standard typewriter keyboard mounted in a drawer so that it is out of the way when not needed, and a sealed clock.

Operation of the unit is simple. The bar code reader is used to identify animals, cages, feeders, rooms, and operators unequivocally. After an animal has been identified, it and its food and water can be weighed on the scale while the information is automatically recorded on the disk. Other information about the animal's condition can be entered simply by touching the transparent panel over appropriate words or phrases on the CRT; the selection of these phrases and words is left to the primary investigator when the unit is initially programmed. Unusual information not covered on the CRT can be entered in English through the typewriter keyboard. Subsystems within the microprocessor alert the operator to missing measurements or observations or to an abnormally large variation between consecutive observations on the same animal—as might be the case if two animals were interchanged. The date and time of each observation are also recorded automatically.

The two floppy disks can contain 10 to 14 days worth of collected data. At regular intervals, these data can be transferred to a larger computer, where the data is compiled, compared to historical data bases, evaluated, and presented in a standardized format. Other subsystems now under development will expand the system for automated collection of data on clinical blood chemistry, the laboratory environment, parasitology, bacteriology, and pathology. Individual Toxsys systems are designed according to the specific software and hardware needs of the user. Prices can thus range from $200,000 to $500,000 for the components now available. Considering the importance that animal bioassays have obtained recently and the escalation of time and costs, however, that may be a small price to pay to protect the investment.

—Thomas H. Maugh II