EDITORIAL

Instrumentation

Special issues of *Science* on instrumentation are a challenge. The types and impacts of new instruments and techniques change rapidly and keeping readers up to date is a daunting problem. In addition, some methods have more importance than others to various fields and subdisciplines. Choosing topics from this rich and exciting menu is thus pleasant, albeit difficult. In this issue, most of the topics may appear to be field-specific, but they illustrate some of the important connections of basic science and fundamental discovery to useful applications. For some of the topics, the interest lies in the utility of the instrumentation to solve important problems; for others, the utility will surely come with time. Astute readers will often see applications to their own work in these new developments.

Ions are easy to detect with high sensitivity, but many experiments provide only the molecular weight or formula. Ions of different structures have different mobilities when they move through a neutral gas under the influence of an electric field, and Bowers, Kemper, von Helden, and van Koppen describe a method of separating ions by their mobilities. Ion chromatography allows separation by electronic states or isomeric structures, and it provides information about these important, hard to ascertain properties. For example, one can determine whether a large all-carbon molecule is a linear chain, a cyclic ring, or spheroidal structure, and whether these structures can isomerize.

The powerful new methods of scanning tunneling and atomic force microscopies (STM and AFM) have revolutionized our view of surfaces. Because they view the surface at the atomic scale, however, the possibility of changing the surface while probing it is a substantial concern. Defects in surfaces are often observed with STM, but AFM often reveals smooth regular surfaces. Ohnesorge and Binnig report that AFM can be used to study surfaces without changing or damaging them. If the tip forces are too high, AFM will deform the surface and make it appear regular. At sufficiently low tip forces, however, the surface can be observed without modifying it, and defects can be seen.

Separation is one of the most important aspects of instrumentation. Samples are frequently mixtures, and the mixture must be separated into its individual components in order to analyze it. In many cases, the separation technique itself provides important information about the composition, since the way in which the components separate tells us about their structure. Giddings describes the use of field-flow fractionation, a chromatographic method that can separate macromolecules, colloids, or particulates in the 1-nanometer to 100-micrometer size range. Electric fields drive components into the laminae of the stream while it is flowing through a thin channel.

Veblen, Banfield, Guthrie, Heaney, Ilton, Livi, and Smelik discuss the application of transmission electron microscopy to minerals for studies of disorder and reactions. The chemical and physical properties of minerals are largely controlled by crystal defects, and reactions occur at scales below the resolution of conventional light microscopes. High-resolution transmission electron microscopy helps provide an atomistic basis for understanding the kinetics of geological reactions and allows the influence of inclusions and intergrowths on the chemistry of minerals to be studied.

Finally, Dabberdt, Lenschow, Horst, Zimmerman, Oncley, and Delany describe atmospheric exchange measurements at the earth's surface. The atmospheric boundary layer provides the medium of exchange between the biosphere and the troposphere. Measurement of trace species emissions and losses is critical to understanding our environment. In order to develop an accurate picture of these exchange processes, measurement issues such as sampling rates and introducing distortions into the flow of air masses must be carefully evaluated.

Instrumentation is a major driving force in current scientific progress. It increases efficiency, provides new insights, and allows us to solve new problems. The mix of inventions, developments, and applications has worked well in the past. As the articles in this issue demonstrate, it continues to be effective.

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