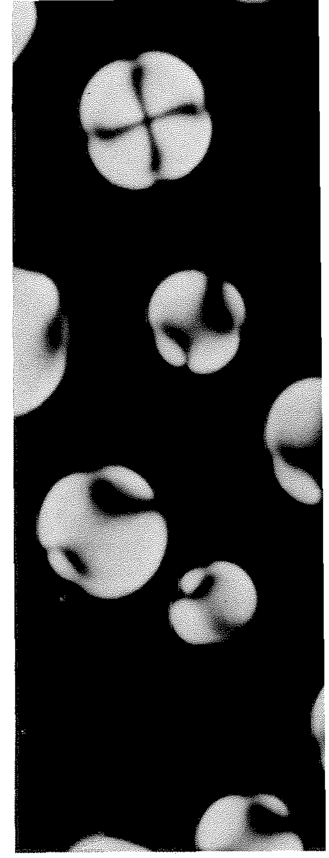


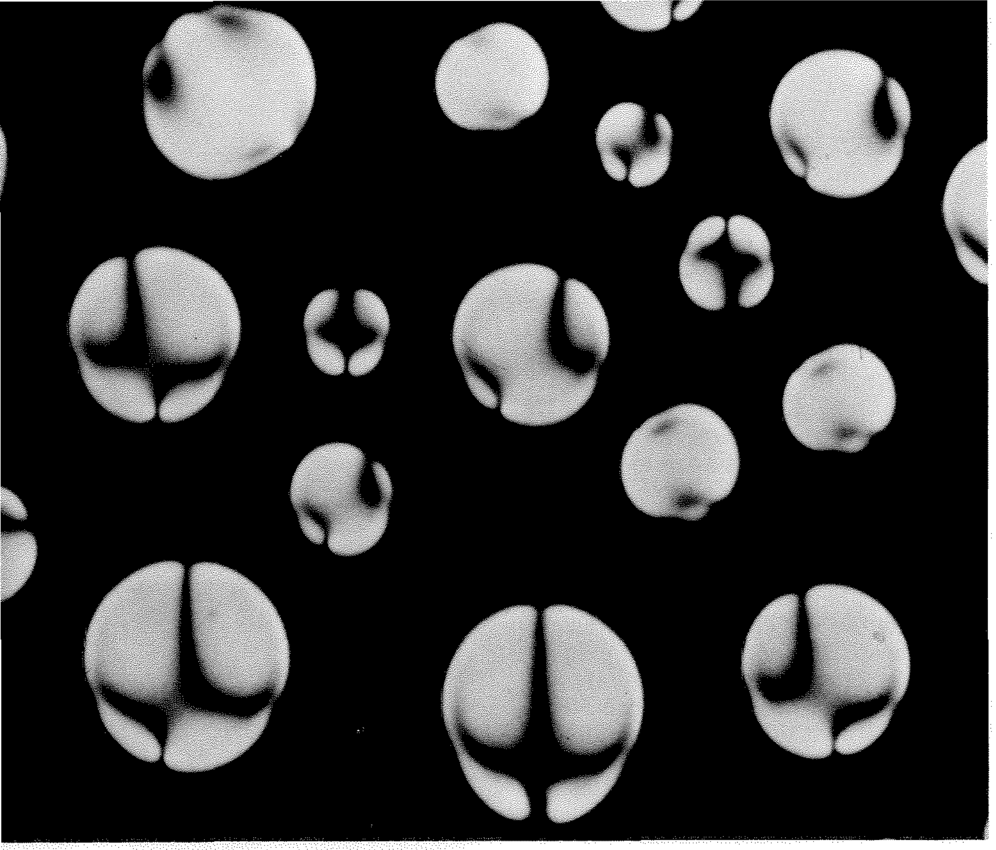
Liquid Crystals

Liquid crystals constitute a unique state of matter with the mobility of liquids and the optical properties of solids. Whether they are a pure state of matter in the classic sense is arguable, but they are an important, though relatively unstudied, kind of material. Among other things, they are the basis for highly accurate mapping of heat patterns on surfaces; they can be used as chemical solvents that permit precise spatial orientation of molecules in a solution; they can detect radiation at different wavelengths; and they may appear on the commercial scene shortly in the form of vivid display devices that can't be washed out by bright surrounding light. And perhaps even more significant, because many basic life processes involve liquid crystals, they may someday provide us with increased understanding and control over those processes.

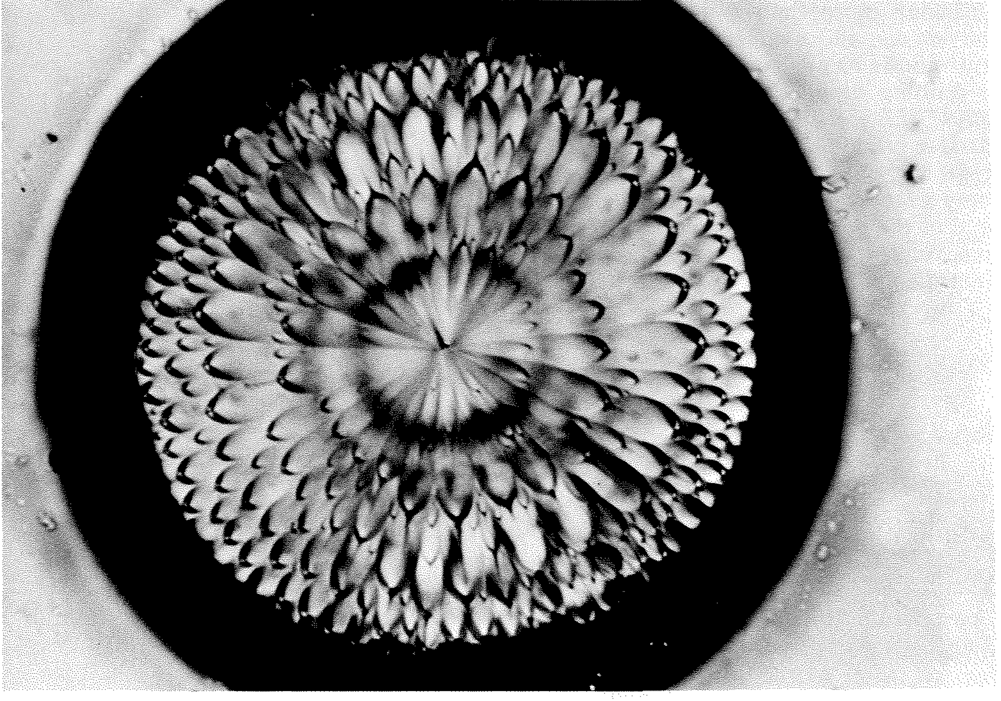
Liquid crystals derive their properties from the particular alignment that their elongated molecules tend to assume. There are two major classes of liquid crystals. One, called thermotropic, is prepared by heating certain organic compounds. The second is a mixture of two or more compounds—and can be as simple as soap and water in the right proportions. The thermotropic compounds have been the focus of most of the attention—particularly some derived from cholesterol, which exhibit striking color changes in the presence of relatively weak external changes, such as temperature, chemical environment, physical stress, or applied electric field.

Liquid crystals were first described in 1888 by an Austrian botanist, Frederick Reintizer, but following some modest research in the years following, the field was inactive by the 1930's. Its revival began in 1957 when two inorganic chemists, Glenn Brown and his graduate student W. G. Shaw, published a long article in *Chemical Review* that recapped previous work and suggested applications and implications for modern science.

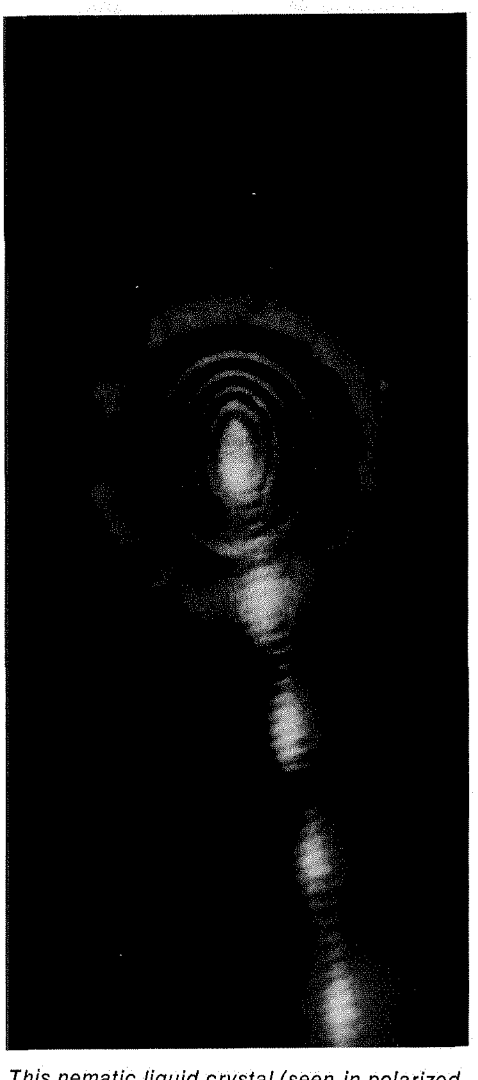
The turbid material in this tube is a type of nematic "threadlike" liquid crystal known by the chemical shorthand MBBA, one of the few known to exist at room temperature. It was prepared by heating the constituents; if further heat is applied—such as a match flame—the MBBA would change to a clear liquid, recrystallizing when it cooled again.



These are droplets of the liquid crystal MBBA, formed in the process of cooling from a liquid phase. Viewed in polarized light, the liquid is black while the droplets show the birefringence characteristics of crystal structure.



This droplet of the most highly structured class of liquid crystal, seen in polarized light, displays a pattern of conic sections characteristic of the particular compound.

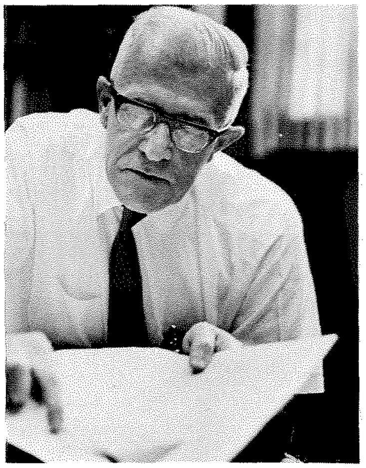


This nematic liquid crystal (seen in polarized light) is deformed by the very intense visible light of a laser.

An International Research Center at Kent, Ohio

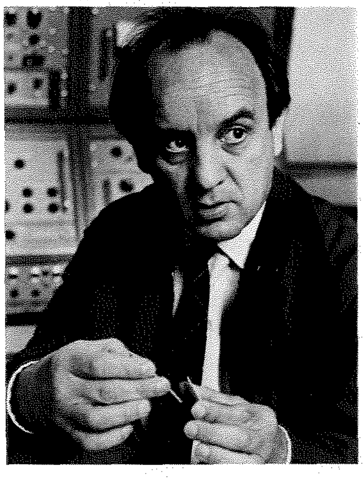
By the end of the 1960's, Glenn Brown had made the Liquid Crystal Institute at Kent State University preeminent in the field; the number of scientists studying liquid crystals had grown from a handful to several hundred; and liquid crystals had burst into public view with six pages of vivid color photographs in *Life* magazine. Even more recently, early in 1970, liquid crystal research was the focus of some added, although unwelcome, attention when dissident students at Kent State, claiming the Liquid Crystal Institute was engaged in war research (apparently because it gets research support from the Air Force Office of Scientific Research), made it a major subject of their complaints. The Kent administration, in denying the accusation, pointed out that the research is initiated by faculty as a result of their specific interests in fundamental chemistry or physics; that like all research at Kent, liquid crystal research is unclassified and open for publication and public discussion; and that all projects involve both faculty and students working for graduate degrees in chemistry or physics.

Today more than a dozen chemists, physicists, and biochemists at the Institute and in Kent's academic departments are doing liquid crystal research. But, says Brown, that kind of diversity exists at few other places in this country. He regrets that too many scientists are still only vaguely aware of work done so far and of the potential impact on their own research of what he says is "the hottest interdisciplinary field in science today."

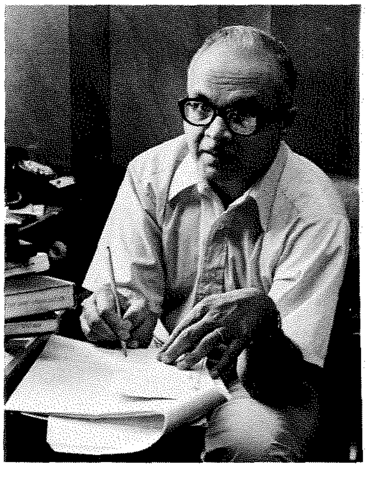


Glenn Brown, Regents Professor of Chemistry and Director of the Liquid Crystal Institute, has nurtured liquid crystal research ever since he and one of his graduate students "rediscovered" it in the mid-1950's.

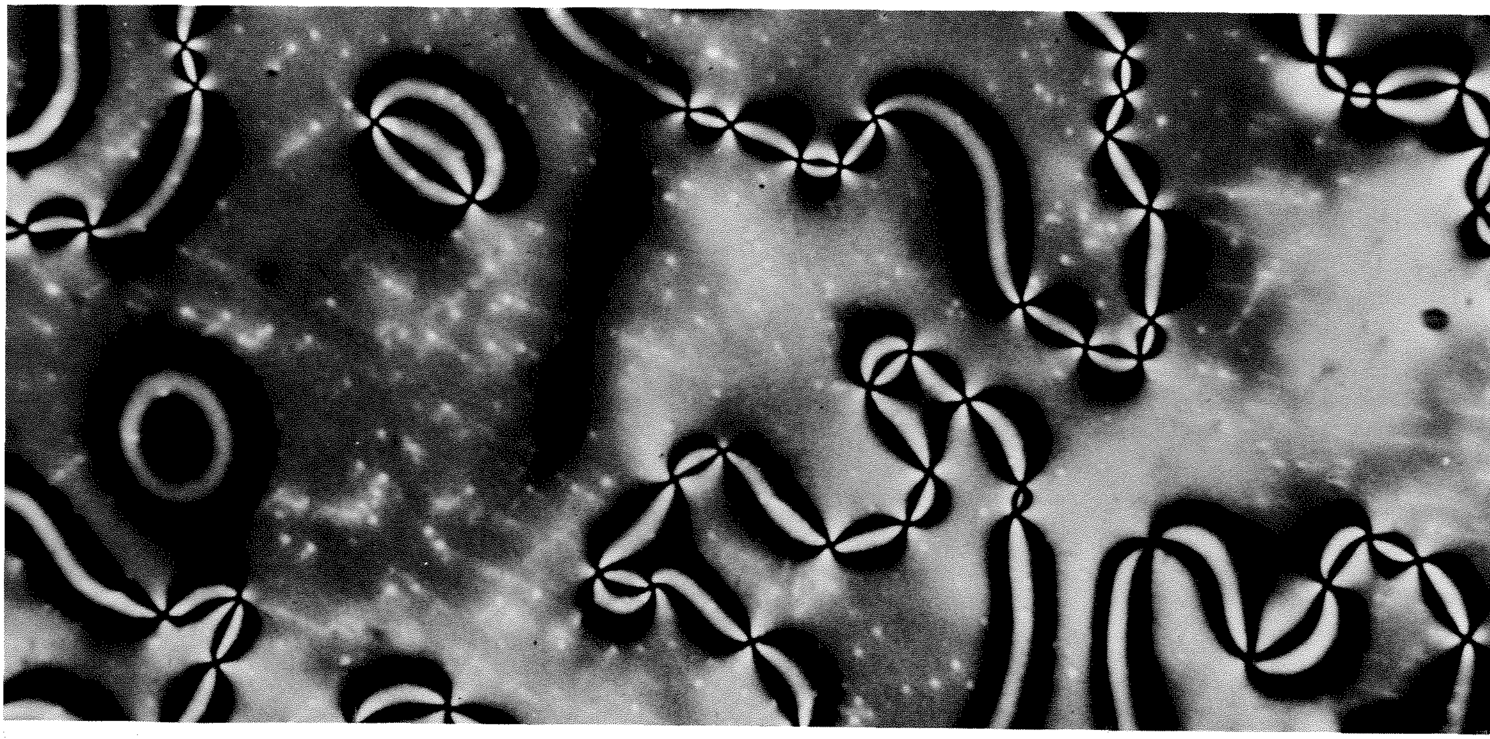
In a demonstration of heat-induced color change in cholesteric liquid crystals, James Fergason has sprayed the crystals on a girl's hand. The spray is black upon application, but quickly changes to hues of blue and green in response to local body heat. The color change results from a "twist" in the molecular arrangement that winds and unwinds—changing the refraction of light—as a function of temperature. Fergason has been using a similar technique in an experimental clinical program to detect breast cancer, and reports high accuracy of diagnosis at low cost per subject.



Alfred Saupe, Professor of Physics and Research Associate in the Liquid Crystal Institute, is making high resolution measurements of the molecular structures and sizes of liquid crystals, as well as trying to learn more about the forces that cause the orientations of molecules in them.



Roger Mishra is trying to show that many biological functions are dependent on the liquid crystalline state of matter. His three particular areas of interest are the roles of liquid crystals in fatty deposits in animal arteries, in the interaction of carcinogens and a kind of protein believed to regulate DNA behavior, and in the activity of brain cell membranes. Mishra, Chairman of the Department of Biophysics at the All-India Institute of Medical Sciences, has just completed 15 months at the Liquid Crystal Institute on an NSF Senior Foreign Scientist Fellowship.



All the molecules along any black curve are aligned in the same direction in this polarized light view of the nematic crystal MBBA.

This nematic liquid crystal seen in polarized light reveals the internal threadlike structures which are the result of spontaneous orientation of the molecules along their long axes. In this relatively thick specimen (about 100 microns) of MBBA, the thicker threads are on the surface, and the thinner ones are connected to the surface only at their ends.