with maximum detail. This corresponds to the attitude of the telephone engineer who is concerned with transmitting the human voice but who is indifferent to the meaning of the messages. Einstein's attitude implies that the messages may have meaning, the particular meaning to be conveyed determining what message is selected. Just as no amount of telephonic circuitry will engender semantics, so does "reality" seem beyond experiment as we know it. It seems arbitrary, however, to conclude that the problem of reality is meaningless or forever irrelevant to science. It is conceivable, for example, that a long sequence of alternating measurements on two noncommuting variables carried out on a single system might suggest new kinds of regularity. These would, of course, have to yield the expectation values of quantum mechanics.

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# *Technical Papers*

## An Approach to the Microscopy of Molecules

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During the course of taking a number of electron micrographs of very thin evaporated metallic deposits, it has been noticed that under certain conditions the discontinuous distributions of particles have been subject to strong orienting effects. The general behavior of these deposits and their appearance under the electron microscope have received considerable attention during the past several years, and excellent photographs by Levinstein (*1*), Sennett and Scott (*2*), and others have confirmed the existence of isolated agglomerations of metal which appear to conform to the prediction of a theory of Lennard-Jones (*3*).

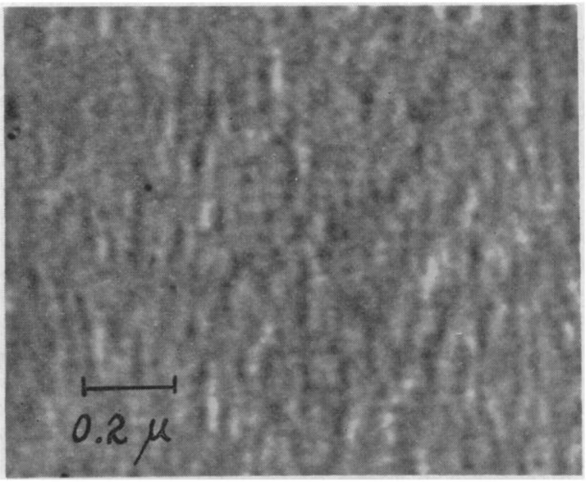

Fig. 1. An evaporated deposit of silver (av thickness, 10 A) on collodion. Note beadlike structure of the dark metallic particles.

Fig. 1, which is an electron micrograph of a silver deposit of average thickness of the order of 10 A on collodion, illustrates this orienting effect and shows an elementary structural unit that is circular in form, with a corresponding tendency for these units to link up and form a linear beadlike pattern. The explanation given for the existence of discrete particles is that the metallic atoms or molecules upon arriving at the substrate surface give up enough energy upon contact so as not to re-evaporate, but retain an energy sufficient to resist being bound in place. Since in general the binding of a metal atom for another metal atom is large compared with the binding to the organic material composing the substrate, the metallic atoms then tend to drift about on the surface until (*a*) they coalesce with a metallic particle or (*b*) lose enough energy before collision with a metallic particle so that they become bound by the substrate.

Although the foregoing explains the appearance of the small circular units, the linear orienting effect remains to be accounted for. One possibility considered was distortion of the microscope. However, there has been no dependence upon position in the field or any geometrical symmetries of the patterns. As Figs. 2–5 show, there is no systematic optical defect to be found. Another possible cause that was quickly disposed of is the motion of the object during the exposure interval. This may give a somewhat similar result, but

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[1] The author takes this opportunity of expressing his gratitude to J. F. Rinehart, of the University of California Medical School, for the use of the electron microscope and to E. I. du Pont de Nemours and Company for preparation of the nitrocellulose samples.

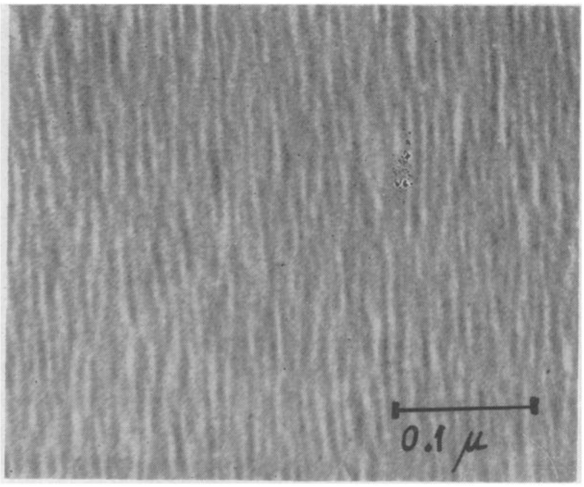

**Fig. 2.** Mapping of nitrocellulose molecules by 10 A of gold Molecular length, .09 μ.

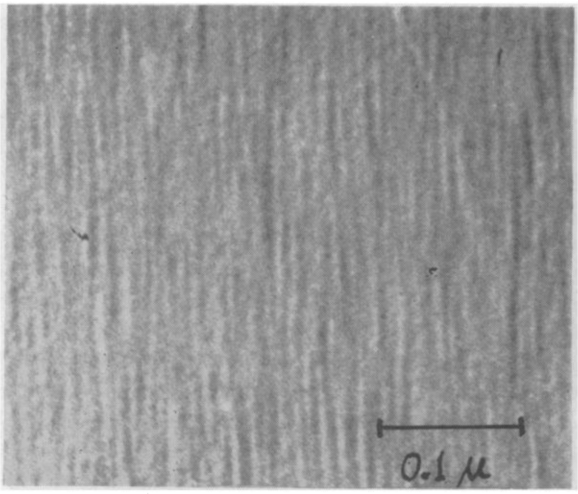

**Fig. 3.** Mapping of nitrocellulose molecules by 10 A of gold. Molecular length, .48 μ.

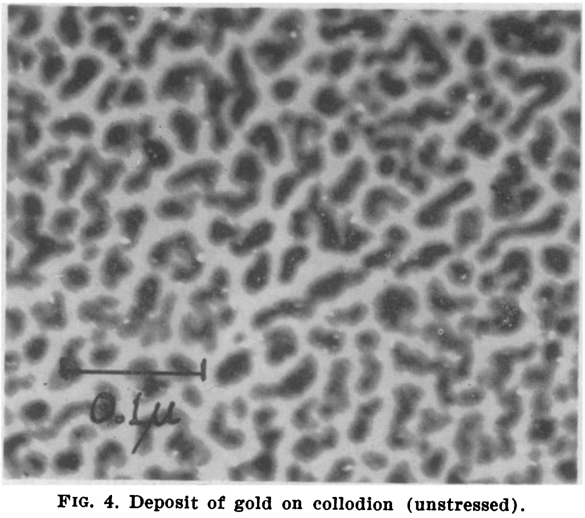

**Fig. 4.** Deposit of gold on collodion (unstressed).

pictures showing forked patterns, for example, were obtained that would have been smeared out by motion of the object. In addition, larger particles that had been intentionally placed on the specimens showed up as undistorted images.

A remaining explanation is that the effect is due to actual structure of the substrate material, in particular to linear molecules themselves. Since the collodion that had been used consists of a distribution of polymer lengths, some samples were obtained of nitrocellulose that had been separated by fractionation methods into groups with fairly uniform molecular weights and hence polymer lengths. The nitrocellulose was dissolved in amyl acetate, and thin films were formed on a water surface. Both gold and silver in small amounts (av thicknesses of about 10 A–20 A) were deposited by evaporation, and it was apparent that the lengths of the linear metallic deposits depended upon the polymer length of the substrate. Figs. 2 and 3 are of gold deposits on nitrocellulose, the former having an average polymer length of 950 A and the latter 5020 A. The branched, open structure to be expected in a semipermeable membrane such as collodion can be clearly seen. For one particular sample the measured polymer lengths from the micrograph agreed to within about 50% with the result determined by viscosity measurements. For the remaining samples (having longer molecules) the mapping by the metal showed increasing length, but in no case were the mapped lengths as long as the actual molecular lengths. It would appear that using the foregoing techniques molecular lengths in the range 100 A–1000 A are most suitably investigated. The lower limit is set by a combination of microscopic resolving power and the minimum-sized metallic particles that can be produced by conventional evaporation methods, and the upper limit by the competition between the inclination of the metallic atoms to form stable metallic agglomerations, and the tendency to form what may be considered as the metastable map-

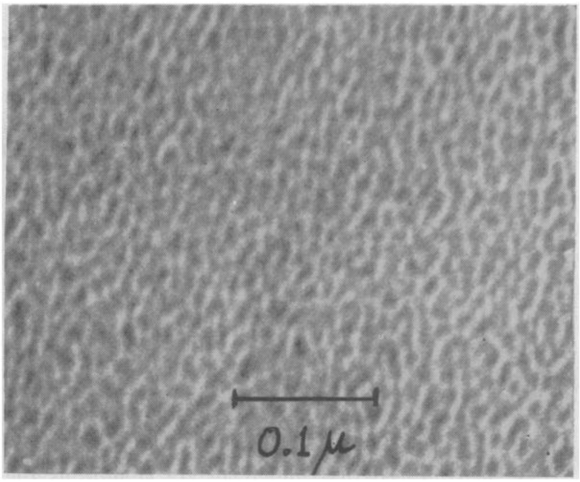

**Fig. 5.** Nitrocellulose molecules mapped out by metallic deposit.

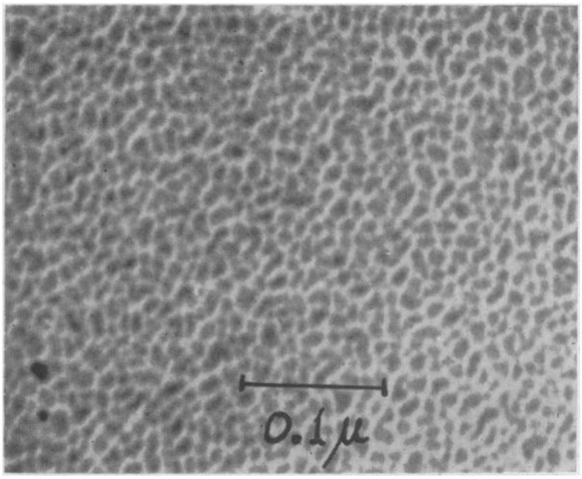

FIG. 6. Same region of the nitrocellulose film as in Fig. 5, after 5 min in the electron beam of the microscope.

ping configuration, the latter becoming less the higher the degree of asymmetry of the substrate.

During the preparation of the substrate films the molecules are generally in a tangled state, and in order to draw them out into a linear structure it is necessary to produce local stresses. This occurs naturally during the drying of the films, and it is only necessary to hunt for regions that have been strained in order to find the desired linear effect. Fig. 4 shows what appears to be a mapping of the molecules in an unstrained state with the polymers lying in a tangled or skein-like configuration.

Figs. 5 and 6 are of the identical portion of a gold deposit on a nitrocellulose film, the former being exposed as soon as a focus was obtained, and the latter exposure made 5 min later, the object remaining in place in the electron microscope and subjected to the 300-μa electron beam between pictures. It will be noted that, whereas Fig. 5 shows most of the particles connected with others, Fig. 6 shows that the metal formerly lying in the connecting filaments has, under the excitation of the electron bombardment, migrated to the larger metallic groups, with the result that the particles have drawn themselves into more stable configurations.

This phenomenon clearly supports the mechanism discussed above as to the formation of these structures. The method is not "shadowing" in the sense that this term is employed in the preparation of transparent objects for electron microscopy; because of the migration of the metal atoms after they arrive on the substrate the structure seen in the present manner is another order of magnitude smaller.

Although an obvious step toward improvement of the resolution of this process would seem to lie in applying Levinstein's finding that metals having higher melting points will form smaller particles, it happens that some metals, palladium and nickel in particular, form continuous films in such thin deposits that the mapping is not striking. Thus for the configuration of the metallic deposit to be responsive to the details of the substrate, it is necessary that the metal used be one which shows a distinct tendency toward migration.

It might be mentioned that the present procedure is a close analog to the conventional staining of specimens for observation under the light microscope; in both instances the contrast between object and background is increased by the selective absorption or attraction of some material having a high stopping power for the radiation being used.

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## Peptide Structure and Denaturation of Proteins

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The denaturation of proteins has been described in terms of altered solubility, appearance of functional groups, and change of shape of the molecule (*1*). It has been reported from this laboratory that absorption spectra data at 205 mμ can be correlated with the peptide structure of proteins. It was hypothesized that any alteration of configuration of the protein might have an influence on the absorption due to the peptide bond by changing the electron configuration of this bond. In a series of preliminary experiments very dilute solutions of bovine plasma albumin were heated to 100° C, and immediately chilled at given intervals. The optical densities of these solutions were determined. At the concentrations used and under the conditions of the experiments, no turbidity was formed and the solutions were optically clear. The optical density rose markedly to values which depended on the concentration of protein (9–40 mg/l) and on the time of heating. After the initial rise the density showed a gradual fall with continued heating. This type of curve is qualitatively confirmed, but the quantitative confirmation is not very good. The maximum rate of rise in density occurs in a matter of seconds, and it is conceivable that the quenching of the initial rise has not been reproducible under the conditions of these preliminary experiments.

During this early work it was also observed that if a concentrated solution of the protein (about 1%) was rapidly heated to a boil and immediately cooled, a precipitate formed during the heating. This precipitate on dilution dissolved to an optically clear solution. The precipitate was more soluble in water at pH 3.5 and 7.5. If, however, the suspension was heated for 5 min or longer, the precipitate was completely insoluble both on dilution and by alteration of pH and was soluble only at pH about 10.

It would appear from this preliminary data that