Molecular Films*

THE forces between molecules of organic liquids of non-ionic type are ordinarily of such short range that they act only when the molecules are in contact. The magnitude of the force depends mainly upon the area, and the nature of, the two contacting molecular surfaces. This principle of independent surface action has been a useful guide in the development of theories of surface tension phenomena and should be equally valuable for theories of vapour pressures and solubilities. It leads directly to the concept of molecules having hydrophobic and hydrophilic parts which spread as oriented monolayers on a water surface.

Such monolayers can have the properties of two-dimensional gases, liquids or solids. A type of film called a duplex film, having no three-dimensional analogue, has two interfaces (an upper and a lower), which are separated by a thin three-dimensional layer (the interstratum).

Expanded films, such as monolayers of myristic acid on acidulated water, are duplex films in which the interstratum is a hydrocarbon liquid. The lower interface contains all the hydrophilic groups. These, because of thermal agitation, constitute a two-dimensional gas that exerts a surface pressure, causing the expansion of the film.

Many proteins, although very soluble in water, form remarkably insoluble monolayers which are duplex films. The interstratum consists of polypeptide chains which form loose loops attached at intervals to the upper interface by hydrophobic groups. These give to the upper interface the properties of a two-dimensional gas. When the monolayer is compressed, some of the hydrophobic groups are driven from the upper interface into the interstratum. The irreversible formation of the monolayers indicates that the globular proteins have an entirely different structure and gives support to the cyclol theory.

The viscosities and elasticities of monolayers furnish information regarding the cross linkages between the chains.

Stearic acid spread on water containing traces of barium salts gives monolayers which can be deposited by a dipping process upon solid plates. By successive dips, any number of layers, up to 3,000, can be built up. Optical measurements, involving interference of light reflected from the top and bottom surfaces, give accurately the thickness of the film.

Single monolayers of various substances, deposited upon barium stearate multilayers of critical thickness (about $\frac{1}{4}$ wave-length), are readily visible to the naked eye because of the change of colour. With monochromatic light the thickness of the monolayer can be measured to within about 2A.

The barium stearate multilayers are both hydrophobic and oleophobic (non-wettable by oil). Dipping into dilute solutions of thorium nitrate causes an overturning of the outside layer of molecules, making the surface polar and hydrophilic. Such conditioned surfaces can absorb many organic substances from solution, giving observable increases of thickness. This technique serves as a valuable tool in biological investigations.

Free stearic acid in barium stearate multilayers can be dissolved out by dipping the film into benzene containing 1 per cent alcohol, leaving a skeleton of unchanged thickness, but of refractive index which may be as low as 1·2. The application of a drop of oil fills the pores of the skeleton without wetting the surface and restores the original colour. Films of many substances may be deposited upon skeleton films and the permeability of the deposited films to liquids or vapours can thus be measured optically.

* Substance of the Pilgrim Trust Lecture delivered by Dr. I. Langmuir, For. Mem. R.S., before the Royal Society on December 8.

A Primitive Philosophy of Life*

IT has been rather the fashion of recent years to make too light of what is known as the comparative method in anthropology, used with such effect by Sir Edward Tylor and perfected by Sir James Frazer. So much of the work Frazer has done in that field is now taken for granted, that we are perhaps too prone to forget that but for the comparative work done by him, much of the intensive investigation into particular areas which is now possible would scarcely have begun to take place. In the present lecture, a hypothesis is put forward in regard to certain conceptions on which Sir James has had much to tell us—conceptions of life.

That conception of life which forms the subject of the lecture was first thrust on Prof. Hutton's attention when investigating the head-hunting practices of the Naga tribes of Assam. The Karen apparently regard the soul as leaving the body and proceeding to the underworld, where eventually it becomes a vaporous substance in a bladder or egg, which bursts, and the contents spread over the fields, fertilizing the developing flower of the rice plant and other herbs of the field. This seems to embody a conception of life as a material finite substance—a vaporous matter, limited in form and extent, and on the possession of which the propagation and renewal of life depends. It is to be noticed that this condensation of the life substance does not take place immediately after death, but the shade of the deceased continues to exist in a land of shades as a sort of separable soul, before the pupating process, which precedes the next manifestation of the psyche as a sort of fertilizer of vegetation. Clearly the belief of the Karens is not

* A Primitive Philosophy of Life. By Prof. J. H. Hutton. (The Frazer Lecture, 1938.) Pp. 24. (Oxford: Clarendon Press; London University Press, 1938.) 2s. net.