Film Reactions as a New Approach to Biology*

THE colloidal properties of living matter are due to the fact that an exceptionally large fraction both of material and of energy is present in films, membranes, fibres, fine capillaries, and the like. In his presidential address to the Chemistry Section Prof. E. K. Rideal has re-emphasised the importance of the fundamental concepts introduced by Sir William Hardy and Dr. I. Langmuir as to the structure of matter in this boundary state. Many of the modes and types of reactions which can be effected in monolayers, and which can be defined with precision, and their mechanism established with a considerable degree of assurance, are unique for such interphases but are again observed in living and organised material. Many 'vitalistic' models have been proposed in the past, and whilst it might be correct, although unscientific, to suggest that the ultimate level of integration in living matter is incapable of examination and definition, yet one is justified in asserting that at least one of the important levels to which due attention must be given for a proper understanding of biological activities is that of the ordered interface.

Besides the static properties such as form, composition, and orientation, that must be studied, the dynamic properties of ingress and egress of flow and chemical action in and with the two dimentional contents of the phase are particularly significant. From the works of *W. Gibbs, Hardy and others, a great deal is* known about how the composition of the interphase differs from that of either of the bulk phases in contact with it, as also how the molecules contained in a monolayer are oriented with respect to one another and to the plane of the interphase. However it is to be noted that as compared with monolayers of simple molecules such as derivatives of both paraffinic and cyclic hydrocarbons, the monolayers both of macromolecules as well as those of binary and components of a higher order, possess a number of interesting and somewhat unexpected properties. The chains are extended at the interface and in general, the non-polar side-chains penetrate into one (the non-polar) and the polar side chains into the other (the aqueous) phase. This relative orientation can be altered by extension or compression. If the molecules in the monolayer undergo reaction with a reactant dissolved in the substrate, the rate of reaction may be modified by the change in the molecular orientation of the former. (It is interesting to note in this connection that these film reactions can be carried out with minute concentrations of strongly absorbed reactants, sometimes even as low as $2{\cdot}5 \times 10^{-6}$ per cent. as in the case of attack of lecithin by snake venom.) There are also several processes in which an alteration in the properties of an interphase brings about a number of varied biological processes of great importance such as phenomena of lysis, agglutination, sensitisation, and the lethal activities of certain substances on various types of cells and micro-organisms.

In two component layers the two molecular species are adlineated in respect to one another, and it should be possible to form relatively stable two component complexes which in three dimensions would only be detectable in terms of mutual solubility and which when a mutual solvent is present as a third component might not be observable at all. Indeed strong complexes are formed in mixed monolayers of a variety of substances such as saponin with cholesterol or digitonin or cetyl amine or sulphate with cholesterol.

From the biological point of view the most interesting property of these systems lies in the mechanism of their formation, for on injection of one of the reactants beneath a monolayer of the other, it is found that a penetration of the latter by the former will take place first and then the formation of a complex monolayer by adlineation. Some substances such as digitonin or cetyl sulphate or amine possess remarkable reactivity in respect to penetration of monolayers of cholesterol. Other substances such as sodium oleate, cetyl sulphate, or psychosin, when injected beneath a protein monolayer, disperse it on account of their stronger associating reaction and cause a solution of the protein in *the form of a protein-reactant complex.*

By spreading monolayers with various head groups and examining reactions caused on injection, it is possible to identify the reacting group in the protein layer. A characteristic group of protein complexes formed in monolayers are the lipo-proteins, such as the gliadin-cholesterol complex. In the latter, the cholesterol is anchored to the specific amino and carboxylic groups in gliadin. These penetrative reactions not only involve a new head group interaction but, in many cases, also a breaking of such a head group interaction already existing in the monolayer prior to penetration. Thus lysis of blood cells can be brought about both by protein and cholesterol, and one must hence conclude that it has a lipo-protein surface.

In the case of reactants containing two or more head groups multiple point contacts are made, and the hydrophobic portions can, if possible, pack or adlineate with its neighbours beneath the monolayer, resulting in a composite film of remarkable stability.

A wide variety of substances have been examined for their extent of interaction with protein monolayers and it has been found that there is a direct parallelism between their extent of interaction and their lethal action on paramœcia. The most reactive group in the protein macro molecule is the amino group, the others following in the order

$$RNH_3^+ > RSO_4' > RSO_3' > RCOO' > RN(CH_3)_3^+ > RNH(CH_3)_2^+ > \text{Bile acids.}$$

As regards the hydrophobic portion, biological activity and film penetration commences with

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C_{9} when attached to a very reactive head group, with C_{14} when attached to a poorly reactive group, and reaches a maximum value at about C_{16}. It is interesting to note that it is not necessary for all the carbon atoms to be in the form of a chain but may be enclosed in ring systems.

One can see, therefore, that the Overton Meyer or Traube concepts of biological activity, *i.e.*, lipoid solubility or capillary activity must be modified by the introduction of concepts of specific head group interactions. A study of these reactions, further permits us to investigate the nature of the coatings of cells or unicellular animals and plants, by examining the effects of lipoid or protein penetrating substances on them.

This extremely interesting address of Prof. Rideal closes with a brief discussion of the possible sources of the bioelectric potentials observed in tissues.

M. A. G. RAU.

MAGNETIC NOTES FOR NOVEMER 1939

MAGNETIC CONDITIONS.—The magnetic conditions during the month of November 1939 were quieter than those during the previous month. There were 19 days of *slight* disturbance and 1 day of *moderate* disturbance. No days of great or very great disturbance were recorded during the month. The number of quiet days was 10.

The quietest day during the month was the 22nd and the most disturbed day, the 13th. The actual characters of individual days is shown in the table below.

Dates of the month	Quiet days	Disturbed days	
		Slight	Moderate
1939 November	2 to 8, 10, 16, 22.	1, 9, 11, 12, 14, 15, 17 to 21, 23 to 30.	13

Magnetic Storms.—During the month a *moderate* storm was recorded on the 13th. This was the only storm recorded during the month as against three *moderate* storms recorded during the corresponding period in 1938.

Monthly Characters.—The mean character for the month of November 1939 is 0·70 as against 1·03 for November of last year.

M. R. RANGASWAMI.

Tambyacha Bungla,
Colaba, Bombay 5,
December 6, 1939.

ASTRONOMICAL NOTES

Planets during January 1940.—Mercury will be visible as a morning star for a few days in the beginning of the month and on January 31, will be in superior conjunction with the sun. Venus, moving slowly eastwards relatively to the sun, will continue to be a bright object in the western sky soon after sunset. Mars and Jupiter can be seen to the west of the meridian in the early part of the night. There will be a close conjunction of the two planets on January 7, the angular distance between the two, at the time being about a degree. Mars continues to get fainter, the stellar magnitude being 1·1 (nearly the same as that of Antares) at the end of the month.

Saturn resumes its slow eastward motion among the stars; on January 16, it will be in quadrature with the sun and will still be an interesting object for observation. Uranus has a retrograde motion in the constellation Aries, until January 26 when it becomes stationary. The planet reaches the meridian at about 7·30 *p.m.* and can be seen very near the fourth magnitude star δ Arietis. Conjunctions of the moon with planets will occur as follows:—Mars and Jupiter on January 16, Saturn on January 17 and Uranus on January 19.

Comets.—Information has been received (*U.A.I. circ.* 797) of the re-discovery of Periodic Comet Giacobini—Zinner, on October 15, by Prof. Van Biesbroeck at the Yerkes Observatory. It was a faint diffuse object at the time (magnitude 15), but as it is getting nearer the earth and the sun, it is likely to become bright enough to be seen with moderate optical aid. The comet is due to pass perihelion on 1940 February 17, the computed period being 6·59 years.

T. P. B.