Langmuir-Blodgett films

Organic monolayer imaged

from R.H. Tredgold

THE Langmuir-Blodgett technique has recently aroused considerable interest as a way of forming highly ordered monolayers and multilayers of amphiphilic molecules. With their paper on page 382 of this issue, J.R. Fryer, R.A. Hann and B.L. Eyres establish, for the first time, the structure of an organic monolayer formed by the technique¹. This represents a considerable technical feat and a milestone in an interesting history.

Early work on Langmuir-Blodgett films was confined to fatty acids but recently films have been formed from a wide variety of materials including amphiphilic porphyrin derivatives and copolymers bearing both hydrophilic and hydrophobic side groups in regular alternation. It is possible to synthesize a variety of amphiphilic porphyrin derivatives starting from naturally-occurring materials which have a built-in asymmetry but, because it is extremely difficult to synthesize a pure asymmetric phthalocyanine, it has not been possible to produce an amphiphilic derivative. Remarkably, however, Fryer *et al.* have succeeded in forming a Langmuir-Blodgett monolayer from a symmetric phthalocyanine derivative. Although the layer spacing of Langmuir-Blodgett films can be found from low angle X-ray diffraction, it is much more difficult to find the arrangement of molecules within a layer because some support is necessary and the supporting material is likely to confuse electron diffraction patterns. Such thin films also have a tendency to overheat and disintegrate under the influence of an electron beam. It is thus all the more remarkable that the structure of a monolayer has now been established.

The history of the technique is also of considerable interest. 'Spreading oil on troubled waters' is a technique known since ancient times, and is referred to by Pliny the Elder. The first scientific study to be published was that of Benjamin Franklin². In the early 1890s Agnes Pockels published two short papers in *Nature*^{3,4} describing her studies of monolayers of various materials, including stearic acid, spread on water. Considering that Agnes Pockels was limited in apparatus to what was available in the family kitchen, her achievements are truly remarkable. She established most of the basic technology of what are now known, rather

unfairly, as Langmuir films and obtained a value of about 2.3 nm for the length of a stearic acid molecule, in reasonable agreement with the actual value of 2.5 nm. In 1917, Langmuir published some of his experiments and in 1920 he described the transfer of a fatty acid monolayer to a solid substrate⁵, acknowledging Miss Katherine Blodgett "for carrying out most of the experimental work". In 1935, Katherine Blodgett published a lengthy paper⁶ describing the formation of multilayers and their characterization; such layers are now

invariably known as Langmuir-Blodgett or LB films. The next significant development was the use of Langmuir-Blodgett films to study the interaction of dye molecules by Kuhn and his collaborators during the 1960s and 1970s⁷.

Subsequently, interest in Langmuir-Blodgett films has increased. Apart from their intrinsic scientific fascination, they have considerable technical potential in non-linear optical wave guides, high resolution electron beam resists, sensitive gas detectors and high efficiency solar diodes. Two special editions of *Thin Solid Films*^{8,9} devoted to this topic give a general idea of modern developments and interests. □

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Neuronal development

Serotonin-containing cell charged with growth cone arrests

from I.A. Meinertzhagen

IF THE developmental neurobiologist would dare re-write Sherrington's metaphor for the brain as "an enchanted loom where millions of flashing shuttles weave a dissolving pattern"¹, then the shuttles might very well be the growth cones, the motile organelles which spin out the tips of all growing neurites, so weaving the fabric of the developing nervous system. Knowledge of factors which determine the course of these organelles or which influence the decisions they make during their progress is therefore essential to any understanding of the assembly of developing neural circuits. Recent studies, *in vivo* and *in vitro*, indicate the nature of some of these signals. Nerve growth factor (NGF)², the surfaces of other cells³ and of the extracellular matrix⁴, and electric fields⁵ have all been shown to have direct effects on growth cones. A recent report in *Science* puts forward neurotransmitters as the latest candidates for growth cone signals⁶.

Individual identified adult neurones of the snail *Helisoma*, when cultured *in vitro*, form growth cones and extend neurites. P. G. Haydon *et al.*⁶ report that serotonin (5-hydroxytryptamine) selectively inhibits the extension of exploratory filopodia from growth cones of the neurone known as cell 19 in the buccal ganglion. As a consequence, outgrowth of neurites is arrested, an effect that is reversible. The action of serotonin is localized to the growth cone, as it can be produced by focal application from a micropipette placed on the surface of growth cones which have been isolated from their neurites. These results reveal for the first time that a substance hitherto known only as a neurotransmitter in the nervous system also has a morphogenetic action, *in vitro* at least. The only previously

known chemotropic agent that directly influences neurite extension at the growth cone is NGF, which increases filopodial exploration and accelerates the extension of neurites from dorsal root ganglion cells of embryonic chicks. These actions are accompanied by progressive turning of the growth cones toward the NGF source.

Inhibition of growth cone motility by serotonin has implications for the formation of synapses between neurones. When a *Helisoma* buccal ganglion cell 5 is axotomized *in situ*, it grows extensive neurites⁷. It also develops stable electrical coupling with other cells 5 and transient coupling with other identified neurones. It does not, however, establish coupling with cell 19 and other buccal protractor motor neurones⁷. The coupling, presumably mediated by gap junction contacts, is found only after axotomy and not in the circuitry of the normal buccal ganglion. When individual neurones are isolated from the adult ganglion and placed in dispersed-cell culture, their behaviour resembles that following axotomy: they undergo neurite growth and become electrically coupled⁸. In this case, however, cells 19 and 5 become coupled, apparently because they are concurrently producing neurites. When such neurones are added to an established cell culture, they may form elaborate co-extensive neurites with the older cells but nevertheless fail to become coupled to them, suggesting that competence to couple electrically is a manifestation of simultaneous growth⁸. Haydon *et al.*⁶ reason that if serotonin inhibits such growth, it might also inhibit the appearance of coupling. They show that serotonin applied to a mixed culture of cells 19 and 5 both selectively inhibits neurite extension in cell 19

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