than usual outside their meeting-rooms, and the engineering section, among other visits, contemplates one after the meeting to the important hydro-electric works in the west of Scotland. It is not apparent from the programme that the zoological section is as yet concerning itself with the fauna of Loch Ness; but it will find special interests both in land excursions and in the fisheries. The important research institutions in the vicinity of Aberdeen will receive close attention from the sections interested (see NATURE, Aug. 18, p. 258). The general (as distinct from sectional) excursions (see NATURE, July 21, p. 110) are lavishly arranged, and it is hoped that as many members as possible will help the vigorous local organisation by indicating in advance, on the form provided, the excursions in which they wish to take part. The hospitality of the city and the

university has proved itself already, and members will not fail to show their appreciation of it.

It is impossible here to enter into fuller details of the programme, but one point may be added. There is a tradition in the Association that Scottish meetings are always 'good' meetings. As a matter of fact the present writer, in a number of years' experience, has never been actively conscious of a 'bad' meeting, though there may have been degrees of goodness. But there is apt to be at Scottish meetings a certain special quality of enthusiasm, both among local scientific workers who take part in the arrangements and in the programme, and about the audience recruited from interested local residents. The article in last week's issue of NATURE affords sufficient evidence that the Aberdeen meeting will not fall short of this standard.

Morphology and Biochemistry

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THOSE who are accustomed to ponder the ultimate problems of biology are aware that though the need for a comprehensive biological science is great, the difficulties in obtaining it are equally considerable. Such old antitheses as that of form and function need not, indeed, detain us, for as Woodger's analysis¹ made clear, form is simply a short temporal slice of a single spatiotemporal entity. The main difficulty which confronts the biologist concerns the fusion of the two great realms of morphology and biochemistry or biophysics. Because at the present day the biochemist has little enough to offer towards the solution of the problem of the maintenance of organic form, the morphologist is apt to suppose that no connexions exist, and to acquiesce in an acceptance of the ancient Aristotelian distinction between *materia* and *forma*. This, however, is a counsel of despair.

In much physiological thought of the past there was a tendency to forget altogether about the problem of organic form and to treat the reactions proceeding in the body as though they took place in some homogeneous medium. The rise of colloid science almost acted as a lightning conductor for these minds by allowing them to salute heterogeneity at one level while forgetting it at the higher ones. But the advance of biochemistry itself has demonstrated that organisation must be taken into account. The significant observation of Vlès and Gex² that the ultra-violet spectrometric curve of the intact echinoderm egg is not that characteristic of proteins though these substances make up by far the largest part of the solid present, and the equally significant finding of Pollack³ that picric acid, a notable coagulating agent of proteins *in vitro*, produced no effect when micro-injected into the cell, pointed the way towards new conceptions. The work of Peters⁴ on the effect of adsorption on the dissociation constants of fatty acids, and

much other experimentation referred to in his Harben lectures bore in the same direction; and recent investigations⁵ of the cell-free extracts of muscle and yeast have indicated the formation of stabilisation products among the phosphoric esters which probably play little or no part in the normal processes of the living cell. Such facts as these do not throw doubt on the value of studying *in vitro* processes, they simply show the need for caution in their interpretation.

For the union of biophysics with morphology the situation is, however, not entirely hopeless. It must be always borne in mind that form persists down to the level of organic molecules, and is clearly possessed, for example, by 'crystals' of protein. The possibilities of studying the orientation of these have not so far been explored. The technique of X-ray analysis which has been so successful⁷ in the case of hair and wool, and promises such interesting results with muscle, has not yet been applied to the proteins of the egg-cell. How illuminating might not such an analysis be, when applied to the cell-bridges which Moore⁸ has shown to exist between the cells of the gastrulating echinoderm embryo, or to the primitive connective tissue fibres which are believed by Weiss⁹ to guide the growth of cells later arising? Again, the possibility exists that the origin of dextrality and sinistrality exhibited by certain molluscan eggs in their cleavage¹⁰ may be found in the stereochemical properties of the protein molecules composing them. Finally, we must probably assume that some oriented space-lattice of protein molecules is involved in the polarity which, as Conklin¹¹ and Wintrebert¹² describe, persists and determines cleavage after the movable ballast of the egg is shifted from place to place by centrifugation; and although as yet we know nothing of the way in which the primary organiser works in the amphibian egg, it is at least not

illicit to picture the orientation of protein chains by polar groups carried on a sterol-like structure^{13, 14}.

It is clear that the obscure relations between morphological form and chemical change are open to experimental attack at many points. But there are two prominent misconceptions existing at the present time as to how this should be done. On one hand there is a tendency to regard the problem as impossibly difficult and to postpone the consideration of it until the Greek kalends. On the other hand, there is a desire to replace the methods of experimental morphology by those of physiology in the hope of obtaining thereby a short cut into the arcana of biological organisation.

Those who support the first of these two outlooks maintain, in their favourite phrase, that organisation in biology must be regarded as axiomatic. "The biologist," says Gray¹⁵, "must . . . accept the living state as he finds it" . . . "It seems . . . logical to accept the existence of matter in two states (the animate and the inanimate) as an initial assumption." Such a point of view appears to overlook the fact that by making biological organisation axiomatic, we correspondingly remove it from the realm of experiment. "As I understand it," he says¹⁶, "the age-long discussion between the mechanist and vitalist schools of thought turns on how far we believe . . . that the facts of biology can be sorted out into a harmonious and satisfying series, without invoking conceptions which are found to be unnecessary in dealing with the facts of observation within the physical world." On the contrary, the inclusion of whatever special type of organisation may be found in living systems, within the sphere of science, has nothing whatever to do with vitalism, which posits some entity in addition to organising relations. The 'irreducibility' of biological categories can receive quite another interpretation, for the laws, for example, of the nematic or smectic state in liquid crystals are similarly irreducible to those holding good for common isotropic liquids. It is for us to investigate the nature of this biological organisation, not to abandon it to the metaphysicians because the rules of physics do not seem to apply to it.

The second misconception arises from an impatience with the thinking that has still to be done on the purely biological level, that is to say, among the 'complex components' of Wilhelm Roux. To suppose that this stage of thought can be avoided is a complete illusion; it is essential to deal first with large packets of factors in a biological organism before proceeding to the finer analysis of smaller packets. Experimental embryology, as may be seen from the admirable recent book of Huxley and de Beer¹⁷, has up to the present been mainly concerned with the influence of part on part in embryonic development. In this way, by observing the behaviour of parts in abnormal situations, the whole array of organiser phenomena was discovered, and a

great deal more knowledge based on transplantations brought into being. Empirical discoveries on the purely biological level thus serve as stimuli to the physiologist to investigate processes which his methods alone would never have revealed in the first place. To characterise experimental embryology, therefore, as "one of the backward branches of biological science" (Wells¹⁸), is to reveal a complete failure to understand the process of biological discovery.

This failure probably originates from a confusion of thought on the part which mathematics should play in science. "Physiological analysis," says Wells¹⁹, "depends very greatly, for its ideas and methods, on physics and chemistry, and in these sciences the emphasis has lain on quantities rather than on shapes." Is not this a false anti-thesis? Both shape and quantity must surely be regarded as ultimately definable in terms of numbers. A topological system or a figure in solid geometry is surely as numerical in its way as a finite number of quantitative weight-units. We are not indeed as yet equipped with the mathematical armamentarium which morphology requires, but this should not be allowed to obscure for us the fact that the central problem of biology is the form-problem. After all, it is essential to realise that although the quantitative in the restricted sense of chemistry has a great part to play in biology, nevertheless arithmetic does not exhaust the realm of logical order, nor is it the only form which scientific exactness may take. There are other systems of structure besides arithmetic, and the complex components may be very faithfully dealt with on their own level. An outstanding example of this is the accuracy of prediction attainable in genetics. They must, in fact, be ordered in this way before they can be linked with physico-chemical knowledge.

We may say, then, that to discuss biology with exclusive attention to matter at the expense of form is, to use the ancient phrase, "Hamlet without the Prince of Denmark". On the other hand, to discuss it with biological organisation regarded as something fundamentally inscrutable, is at least equally futile.

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¹³ Waddington, C. H., Needham, J., and Needham, D. M., *NATURE*, **132**, 239, Aug. 12, 1933.

¹⁴ Waddington, C. H., Needham, J., Nowinsky, W. W., Needham, D. M., and Lemberg, R., *NATURE*, **134**, 103, July 21, 1934.

¹⁵ Gray, J., *NATURE*, **132**, 661, Oct. 28, 1933.

¹⁶ loc. cit.

¹⁷ Huxley, J. S., and de Beer, G. R., "Elements of Experimental Embryology", Cambridge, 1934.

¹⁸ Wells, G. P., *NATURE*, **133**, 890, June 16, 1934.

¹⁹ loc. cit.