OUTLINE OF A NEW MATHEMATICAL APPROACH TO GENERAL BIOLOGY: I

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This first part of the paper deals with the theory of organic form. By introducing a formal principle, it is possible to develop a mathematical theory of shapes of organisms, which covers both animals and plants.

The development of Mathematical Biophysics has made considerable strides in the last years. Not only is the theoretical edifice well erected and systematically developed, but a very large number of experimental facts ranging from cell respiration to experimental aesthetics have been adequately quantitatively represented and in some cases even predicted by the theory.

Naturally, as in every science, the more a theory is developed the more new problems appear in it. Also the more experimental facts have been explained, the more new experimental facts call for an explanation. The progress of any science may almost be measured by the width of the new horizon it uncovers to us.

Whether there is such a thing as a possible exhaustion of a science, a stage in which everything is discovered and nothing remains to be done, is more a metaphysical question, and we shall not discuss it here. Premature worries in regard to the possibilities of explaining some of the yet unexplained phenomena, and anxieties lest such an explanation should turn out to be impossible, should not take place with scientists. Whenever such worries and anxieties have taken place, they usually were rather ridiculed by further developments by investigators who went ahead heedless of such worries.

Nevertheless, at every stage of development of a science, when we have before us a vista of unsolved problems, it is useful, and perhaps even necessary to consider, so to say, the general plan of campaign in attacking those problems. We may not be expected to tell actually how to solve those problems, for that would practically amount to a solution. But we should be able to see at least in principle how those problems may be solved practically.

If we survey from this point of view the field of mathematical biophysics, we find that while in some directions the method of further
conquest is already indicated by merely following and extending present techniques, in some other directions the adoption in the future of new methods and techniques is strongly indicated.

The first case is exemplified mainly by the mathematical biophysics of the central nervous system. We may have to modify somewhat the fundamental equations. But in principle the rather formal method used hitherto, namely the study of geometrically more and more complex circuits, to which the formal, phenomenological equations are applied, still offers almost unlimited possibilities.

The second case is exemplified by the mathematical biophysics of the cell, especially of cell aggregates and of the organism as a whole. While by the introduction of drastic simplifications, a remarkable progress has been made in the dynamics of cell division, as well as in the theory of cell aggregates, yet an impartial survey of the situation shows that it is pretty difficult to even conceive in principle how the present methods are going to be applied practically to some more complex cases. We have outlined a couple of possible approaches to the problem of the form of animals. In principle the development of those suggested approaches should well lead us to the solution of the problem. Practically, however, as it is easy to see even now, we shall soon run into almost insuperable difficulties if we try to extend even the present approximate treatment of the metabolic forces to such complex shapes as are offered by various organisms. Any oversimplification of the problem must have a limit, beyond which the problem becomes completely distorted and unreal and a further simplification of the present “approximation method” would likely exceed that limit. Something else is to be done.

Difficulties of a similar nature but perhaps even more severe in extent, are met when we remember that hitherto mathematical biophysics has studied only a very, very small section of the organic world. The interaction between the organisms and the surrounding environment has been taken into account from the very beginning. This interaction forms often a very essential feature of the theory, as for instance in the case of cell division. Yet the properties of the environment considered have been oversimplified almost to the limit. Only a very small fraction of the environment of an organism is inorganic. The largest part of that environment is formed by other organisms. Almost every organism depends for its existence on the presence of other organisms, with the exception perhaps of some simplest unicellular organisms. With this exception the concept of an organism or even of a number of organisms of the same kind, in the absence of other kinds of organisms, is a fiction.