other, and with films travelling horizontally in opposite directions, might be preferred. Kinematograph lenses and films would then be suitable.

While I attach no importance to the rough numerical results obtained from this first experiment, I do maintain that it indicates that the method of oppositely moving images is capable of giving useful and certain information, and that a meteorological observatory might well be equipped with a special camera designed for higher speeds than my modest pioneer apparatus. Information as to fact can do no harm.

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On Co-ordinated Biological Research.

IF researches dealing with the relation of organisms to the environment are to approach in precision and completeness those dealing with matter and its physical attributes, it is essential that problems like that outlined below should be attacked by a team of workers, working simultaneously and in co-operation. Biological work of this kind may be accurate, valuable, and interesting, and yet fail in completeness for lack of contemporary data, as a review of recent work would readily show.

During recent years I have studied the general biology of oyster populations (*O. edulis*) in mass and in individuals in relation to general environmental conditions throughout successive seasons in different localities. From these studies it is clear that populations vary in their biological manifestations directly with the environment; for example, the incidence of general shell-growth, spawning, sex-change, and fattening can be predicted approximately from a knowledge of the environmental conditions, of which temperature range and rate of temperature change are the most important; the incidences vary in different localities.

It has also been demonstrated that *O. edulis* changes from femaleness to maleness automatically at, or a few hours after, the instant of egg-spawning (*Jour. M.B.A.*, **14**, p. 967; 1927), and it is clear from the studies mentioned above that the main change in the population from maleness or neuter to obvious femaleness occurs just before and during the breeding season: further, the amount of change in the population to femaleness at the beginning of the breeding season depends upon the nature of the environment. There are indeed good presumptive grounds for concluding that certain oysters, which are —or have recently been—male, will begin to produce eggs—whether they still retain sperm or not—provided (*a*) that the food-reserves have attained a certain concentration, (*b*) that the temperature of the medium is above a certain level: hence the occurrence of hermaphrodites. These conditions are not inconsistent with the possibility that certain substances may have hormonic value.

The problem to be solved is, therefore, How much of the sex-change is due to internal or to external factors acting separately? or alternatively, What combination of internal and external factors will maintain maleness or cause the assumption of femaleness? I have stated elsewhere that anything can be a male, but that some more than ordinary attribute is required to make a female. Broadly applied, this statement is true of the oyster, and the obvious preliminary requirement for a functioning female is abundance of food-reserves. Therefore, to obtain *conclusive* evidence of the factors controlling sex in *O. edulis*, it will be necessary in the first place to obtain seasonal chemical analyses of individuals the recent sexual history of which, as well as actual sexual condition at the instant of examination, is known. It can perhaps be predicted that the total rate of metabolism in debutante females will be higher than in the declining and perhaps fully ripe males, but for the clear establishment of the cause of sex it will be necessary to obtain accurate information on this matter correlated with conditions as regards food-reserves. When the results of these researches are known, it is possible that a basis may exist for critical experimental work.

To understand variations in the rate of metabolism and correlate the results in a direct manner with the environment, it will be necessary to know the seasonal variations in the plankton over the natural oyster beds. The seasonal variations in plankton are undoubtedly controlled in part by the supply of limiting food-factors, *e.g.* phosphates, nitrates, and in part by the biological characters of the constituents; it is therefore necessary to know the variations in the limiting food-factors in the area of investigations.

It has been shown that the growth of shell-material occurs at about the periods of the year when the storing of food-reserves especially occurs (*J.M.B.A.*, **15**; (1928), so that the interrelationship of these two processes is also bound up with sex. Shell-growth, however, is a problem which itself demands—besides biological information regarding internal condition—full knowledge also of the physical conditions prevailing over the beds, *e.g.* variations in salinity, temperature, alkalinity, and even general illumination. The experimental analysis of the factors concerned in producing that kind of shell-growth which may occur when oysters are disturbed during the non-growing season (loc. cit., 1928) would be most satisfactorily performed when known natural conditions on the beds can be used as a control. The possibility of predicting the beginning of shell-growth to within a period of one or two weeks (loc. cit., 1928) also offers an excellent opportunity for the study of calcium metabolism, and significant determinations of the seasonal variations in the metallic constituents of the blood.

It is obvious that one person alone cannot investigate all these matters as they should be investigated, that is, simultaneously. For this reason I came to the conclusion, and reported last year, "that a definite scheme of co-ordinated research might now be formulated to attack simultaneously in the future the factors underlying shell-growth, sex and sex-change, spawning and fattening in the oyster, and the more exact relation of these to the environmental—and experimentally controlled—conditions."

A scheme of this kind, it is true, need not be confined to the oyster, but might also be applied to the herring, the plaice, the haddock, the salmon, or other organisms, but it is doubtful if the results from any of these piscine biological subjects would be as valuable from the point of view of fundamental biology as those which might be obtained from a sedentary sex-changing organism like *O. edulis*. There are other species of oyster similar in biological characters to *O. edulis*, and a scheme like that outlined above might be carried to fruition in almost any country, but everywhere great difficulties will have to be overcome. In England there would seem to be little chance of the adoption of such a programme of co-ordinated research, unless there were universal approval and the various bodies interested in fundamental research combined to provide the costs and the personnel.

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