SCIENCE.—SUPPLEMENT.

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BIOLOGY AND SOCIOLOGY.

In an article entitled 'Revolution and evolution,' printed in the *Contemporary review* for September, Mr. Leon Metchnikoff wages war against the opinions of those who would draw a close parallel between the biological relations of a community of zooids and the sociological conditions under which an ideal association of human individuals must occur.

According to Metchnikoff, there is a complete antithesis between the laws of the sociological and the biological domains; for the first have to do with aggregations of individuals maintained by *co-operation*, 'conscious or unconscious,' while the second concerns only groupings which are based on *struggle*. Then the author admits the occurrence of the sociological law in the biological community, but still strictly insists that individual struggle and communal co-operation are two forces of different kinds. He says (p. 432), "Whenever we see a phenomenon of association, — be it in the shape of a vegetable or animal organism, or that of a more perfect human community, — we cannot fail to detect something new, as essentially distinct from the law of individualistic competition or struggle as that specific Darwinian law itself is distinct from the Newtonian universal law of gravitation. That something is, namely, the consensus of a number of more or less individualized forces aiming at an end, not personal to one of the allies, but common to them all, and that is what we call *co-operation*." The conclusion seems to be, that, when we rise from the biological into the sociological domain, we can carry nothing useful from our toilsome studies on the way in which the organisms of nature have been built up and preserved, but must seek out a new law of deliberate altruistic co-operation, which is represented as having no relation to the natural impulse of the individual toward his own advancement.

Far from presuming to deal directly with so complex a question, it is the object of this paper to present the truth as regards one side of the problem by discovering, if possible, the true communal relations of the simplest *differentiae* making up the most complex animal body. It will be pointed out that biological data indicate no final antagonism between co-operation and struggle, but, on the contrary, that the one is the necessary antecedent of the other.

Living matter or protoplasm has, apparently, in all its forms, the same general functions; and such a study of relation as that proposed ought, if carried out on right lines, to lead us to a conception of the philosophy of protoplasm, by which is understood the main impulse or motive guiding individual and determining collective action.

Whatever may be the present and future subjects of biological dispute, the tidal wave of thought has lifted and grounded firmly beyond the danger of overthrow one grand general idea,— that every living organism may be anatomically analyzed into a greater or less number of physiological units — the cells or modified cells — which contain the living matter, and which, in function, though not in form, are like the parts they go to make up. The accuracy of this analysis is not affected by the differentiation of the cells themselves, nor would conclusions from it be disturbed should each cell itself be proved to represent a community of discrete factors.

It has come to be a fundamental doctrine of physiological teaching, that the higher animals may be looked upon as communities of living cells or modified cells whose functions determine the action of the organs they compose, and which are bound together by more or less not-living, intercellular matter, made, or at least modified, by the cells; and yet it appears that some of the most evident and important consequences that arise from this communal relation of different individuals, having needs and powers of all grades of similarity and dissimilarity, have been generally neglected or misunderstood. The analogy between the animal cell as related to the organism, and the human individual in his entirety as related to society, is a very striking one.

The cells of a body all take their nutriment from the same general pabulum: they all have the same general needs; and as the food-supply is a result of constructive effort, and therefore limited in quantity, there must be a struggle for food (or a struggle for existence) among the cells, which would be more severe the more nearly alike their individual needs. This statement will bear an illustration. We know that a blood-free muscle may, by artificial stimulation, be reduced to complete exhaustion; but, if a nutrient solution like blood-serum be now passed through the blood-

vessels, the muscle-substance, by virtue of its chemical affinities, extracts certain matters from the supply-fluid, and recovers its irritability and contractility. Now, we know that this unstable muscle-substance is continually being oxidized with the production of certain waste products. Suppose that the affinities of a given muscle-fibre for food matter are so feeble that less nutriment is brought in a given time into the tissue than is lost in the way of waste: the result is a gradual decadence or atrophy of that muscle. As in the physiological condition the food-supply is limited, those muscle-fibres with strongest constructive chemical affinities rob the weaker fibres, which could only get their fill, as it were, by a modification of physiological activity throughout the whole body. This explanation of the relation of growth to competition probably partly underlies the well-known fact of the extraordinary growth of one of a pair of similar organs, as a kidney, when its fellow is extirpated.

Owing to the physiological division of labor among the tissues, each one of these has come to depend nearly absolutely upon organs far removed for some of the essentials to its welfare: as, for example, a gland is often called upon during secretion to pour out a bulk of material greater than its own volume, and for the performance of this function there is an alteration of vaso-motor activity through which more blood visits the gland in time of need; and this vascular change, as also the secretion itself, is directly controlled by nerve-centres lying in the distant brain. So, elsewhere in the body, we are continually coming upon phenomena in which the working tissue appears to derive little direct benefit from its effort; the activity of each organ seems determined by, or at least co-ordinated with, the needs of its fellows; and this fact, indeed, constitutes the very definition of physiological activity.

If we invent a physiological allegory, whose personages are the animal cells supposed to be endowed with sensibility, reason, and motion, like in kind to the faculties of complete organisms, we should find that the fanciful sketch of the cellular society constructed on such a scheme corresponds remarkably well, if not identically, with the actual result of such associations of cells as we find them in living organisms. The apparent altruism noted above is perhaps most marked in the working of the respiratory nerve-centre on whose rhythmic impulses directly depends the contraction of the respiratory muscles which expand the chest, and thus draw into the lungs the fresh air necessary to the life of the whole body.

This nerve-centre is generally supposed to be composed essentially of a group of nerve-cells occupying an insignificant area of the brain; and on their ceaseless, rhythmic output of energy every living molecule of the body each moment derives benefit without giving any manifest adequate return. Still, though each new study of the body brings to view fresh examples of the subservience of individual needs of the physiological units to the welfare of the community of cells, it can be shown as scarcely doubtful that this altruism, apparently purposive on the part of the living integers, is but an indirect outcome of an effort for their own aggrandizement, their supreme selfishness, as it were. There is the strongest reason to believe that the physiological individual, or cell, in a complex organism, is primarily as completely bent upon its own nutritive welfare, and as regardless of the condition of its neighbors, as if it were a free monad contending for sustenance against a myriad of its fellows in a culture-solution. Even in the case of the action of the respiratory centre, which seems devoted purely to aims benevolent to the organism as a whole, experiment indicates that any such benefit conferred outside the centre itself is, as it were, a mere accident in its activity.

It is the present belief of physiologists that the nerve-cells of the respiratory centre are stimulated by a lack of oxygen to discharge energy into the motor nerves arising from them; and their discharges, up to a certain point, increase in vigor with diminution of oxygen-supply, and conversely become weaker and less frequent when that gas is in excess in the blood. If oxygen fail totally, the cells soon die. Now, suppose an animal to be in a state of respiratory quiescence: oxygen is still being drawn from the blood by every living tissue. As a result of this, there is failure of oxygen in the respiratory centre; and a stimulus of some sort is heaped up in the nerve-cells there, until finally an explosion of energy proceeds from them into their motor nerves, and thence to the muscles of inspiration which cause the chest to expand. Thereby fresh air is drawn into the lungs, new oxygen diffuses into the blood, and thus the excitement of the respiratory centre is allayed for a while, presumably owing to the oxidation in the centre of some irritating chemical products of tissue-change.

It has been found, that, if the manner of circulation is artificially so altered in a living animal that the brain still receives blood oxidized to its normal arterial condition, while tissues of the trunk or limbs get only venous blood or even none at all, the rhythmic action of the respiratory centre goes on undisturbed, though the organs with altered circulation soon die from asphyxia. On the contrary, should the arteries conveying

blood to the brain be clamped, thus cutting off the oxygen-supply and abolishing the removal of waste, or should the blood passing through them be artificially warmed, thus hastening the chemical changes in the nerve-centres without a corresponding increase in the rapidity of food-supply and waste-removal, the deep and energetic breathing of dyspnoea soon shows the pressing need of the centre for fresh oxygen; and the animal may die, as far as its brain is concerned, in the convulsions of asphyxia, though the great bulk of its body is unaffected, and lives on in perfect rest so soon as the exhausted brain can no longer stir its muscles to contraction.

If we arrange a narcotized living animal in such a way as to observe the changes in the amount of its arterial blood-pressure while supplying air by artificial respiration, it will be observed that the pressure rises when the respiration fails ever so little, and the elevation is most marked when the muscular contractions of extreme dyspnoea appear. Now, it is this arterial pressure which drives the nutrient blood on its way. The blood-current is stronger and swifter, the greater the pressure; and the result of such a change is to present each tissue with a more abundant supply of oxygen and other food-materials. The rise of pressure noticed in the first instance was due to the contraction of the living walls of the blood-vessels throughout the body: they responded directly, or were made to respond indirectly through their motor nerves, to the need of the oxygen in their local areas and in the brain; and the result of this action was to supply with all despatch the respiratory centre with whatever store of oxygen there was in the blood. So we have the all-important fact of the mutual helpfulness of the bodily tissues on the one hand, and the respiratory nerve-cells on the other, brought about by the independent exertion of each living factor of the body in its own behalf. Every physiologist knows experimentally how the whole body rises in protest, as it were, at any interference with the free performance of the respiratory functions; and that little group of cells whose business it is to initiate the movements of breathing are thus protected from want by every part of the body, which is itself dependent on them. A complete record of all such co-ordinate actions would form a treatise on physiology, and a consideration of all the results justifies this generalization: that every physiological unit of a complex organism labors for its own aggrandizement alone; but its existence is conditioned by an association with neighbors, with which it must compete and upon which it depends; and this union has the suggestive result that every living cell in the body receives aid and protection from its neighbors in proportion as it, in turn, by its activity, furnishes them with aid and protection.

This remarkable union of the energies of the morphological elements of the body, which suggests so clearly the social relations of an ideal community, finds its explanation in the ground law of the doctrine of evolution. If we but presume the fact of a struggle for existence among the tissue-factors, the survival of the fittest must be a corollary to that proposition; and the fittest individual is that whose life best tends to preserve the welfare of the organism as a whole, for on this depends the existence of each of its constituent parts.

The farther we peer into the mysteries of the living animal, new utilitarian beauties are disclosed with every secret unfolded; and the time is probably not far distant when it will be difficult to point out a structure or function which, far from being simply useless, has not a definite purpose aimed at preserving the safety or perfecting the economy of energy-discharge of the whole body. Even if one bears in mind the well-known criticism on the imperfection of the eye as an optical instrument, his view would be one-sided and unjust if content to rest there. The errors of normal vision are nearly all errors of judgment; which is a subjective process, and it is presumable that finer workmanship in the optical camera would be useless in arousing sensations of greater advantage to the organism.

From a physiological point of view, the physical environment of an animal has only a remote though a certain and most complex relation to changes in the organism. Now, any change of the environment must be followed by a kaleidoscopic alteration in the relations of the tissues among themselves, and these may be very profound without any necessary variation of the total vital configuration. Dr. Romanes, in his recent exposition concerning physiological selection as a means of accounting for the origin of species, has done good service in looking directly at the independent variable — the animal cell — in seeking a solution of the intricate problem presented by the body as a whole.

If this analogy between the communal relations of living cells in the body and those of individuals in human society have a foundation in fact, we ought to be able to use the parallel as a path of research, and, from what is known concerning the evolution of society, gain light as to the physiological relation within parts of the body which yield their facts very sparingly to investigation.

A well-known physiologist has called the central nervous system the final battle-ground of the

science. If we look upon these mysterious nerve-cells as a community of reasoning individuals, we should expect to find a division of labor among them which should restrict more or less completely the physiological activity of each anatomical area. What we know of the subject justifies this comparison. We find the nerve-cells of the medulla and spinal cord inheriting automatic and reflex powers of comparatively simple character, but of vital importance to the life of the whole system; and there is reason to believe that these powers are more extensive and efficient the longer they have been impressed by heredity. When we ascend from the medulla to the cerebellum, we come upon powers of the same kind, but vastly more complex in their co-ordinations; and here, or hereabouts, we meet a new faculty,—that of *learning* reflexes, or learning to carry on a complicated action with machine-like definiteness and celerity in obedience to a given stimulus. The complex motions of walking, balancing, the performance of an experienced pianist, are largely reflexes whose centres, in all probability, lie in this part of the brain. Then we gradually rise through nerve-centre after nerve-centre, with graduated physiological powers, till we reach the Teacher himself, whose energy is, doubtless, that of the cortical cerebral cells. Nothing is clearer in physiology than this general differentiation of function among the nerve-centres, and it is altogether probable that a physiological differentiation even goes hand in hand with the morphological one which histologists have shown to involve the matter making up the individual animal cell itself.

Looking at the cortical cells again as a community, we should expect that the complex of powers of the society should be divided up and portioned off to distinct individuals which should inherit extreme facility of action in a definite province without altogether losing the other, now subordinated, functions with which they were originally endowed. Artificial stimulation of definite cortical areas we should expect to be followed by a manifestation of their specific function; and, on the contrary, annihilation of such a region ought to be followed by a corresponding paralysis, which would not be permanent, because neighboring cells would gradually develop the lost function, the power to perform which had hitherto been latent in them. Each new lesion would be followed by a crippling involving the same features, and the recovery would each time be less perfect. This presentation may be taken, as far as the results go, as the actual outcome of experimentation on the brain; and the same history would be repeated by any civilized community in which the various trades and professions should, in turn, be deprived of their workers.

Physiological phenomena are those in which the activities of various tissues are co-ordinated in such a way as to produce a combined action; and we may consider each tissue-element as a reasoning individual which associates physiologically with its neighbors only so far as a result of this union is beneficial to its own welfare.

Turning now from the normal body to view the phenomena of pathology, we enter a field which has been too incompletely surveyed for us to trace our way at will in it; but so far as pathological processes are understood, they seem to be guided by the same law of endeavor for self-aggrandizement on the part of the living cells concerned, as in those actions already considered. When an arterial wall becomes cheesy or chalky in atheroma as a result of increased arterial strain, we see living tissue-elements redeveloping some of their suppressed embryonic powers of metabolism, and replacing their sentient, overworked protoplasm by an inert substance incapable of either evolving energy or suffering from overstrain. Unfortunately this ostrich-like hiding of the head is an ill-judged attempt at self-preservation; for it entails increased labor on other organs, which may result in fatal inco-ordination. So, also, when a foreign particle within the body is encysted by an envelope of tissue developed for that purpose, the whole process goes on as if the active cells had distinctly in view the covering-up of a hurtfully irritating object.

Those pathological processes which are more usual grade imperceptibly into the physiological; as, for instance, those phenomena of altered circulation and growth attending the healing of the fracture in a broken bone.

Only a competent pathologist could give full force to the proposition here stated: but there seems to be convincing evidence that in pathological as in physiological processes there is a distinct effort, on the part of the acting protoplasm, towards self-aggrandizement; that is, to reduce its expenditure and to increase its income of energy. In the physiological process the various factors work together in such a way that the resultant effort is of the greatest possible benefit to each separate member without detriment to any other. In an extreme pathological action the selfishness of some single individual brings ruin on the whole organism, because regardless of the fact that unlimited self-aggrandizement is hurtful to the remainder of the community. We may profitably compare these two biological conditions to the states of discipline on shipboard as they may be observed respectively in calm weather and during great

excitement. In the first instance every movement is carried out, and every duty is performed, with relation to a common purpose,—the most complete welfare of ship and crew; but no one can doubt that the individual motive of each sailor is to thereby bring the greatest benefit to himself. In the unusual occurrence of threatened shipwreck, however, this co-ordination is lost, because the selfishness of each individual in seeking his own safety causes him to disregard the duty he owes his companions, and the result ant is fatal in-co-ordination.

If what we have said be true, the premise assumed by Metchnikoff is fundamentally wrong. The doctrine of evolution applied to the living organism teaches, not that there is final antagonism between struggle and co-operation, but that co-ordination and the well-being of the whole is the natural outcome of struggle for existence among the individual particles of the body; and, presuming capability of variation, there must, through 'survival of the fittest,' come to be increase of specialization and perfection of performance in every function. Fatal or merely injurious pathological processes, when traced to their source, are found to be due to accidents which do not come under the head of uniform law. Supposing such an accident to occur so frequently as to become a normal event: the vital elasticity of the organism re-adjusts itself to these new conditions involved, so that they (as in the case of the bone-fracture) are hardly distinguishable from ordinary physiological processes.

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THE BRITISH COMMISSION ON THE DEPRESSION OF TRADE.

IN response to a general feeling of anxiety, some of it expressed openly and some not, a royal commission was appointed some months since by the British government to take into consideration the depression of trade and industry in Great Britain, and to report by what means, if any, the depression could be remedied. The final report of the commission has recently been published, and it bristles with points of both theoretical and practical interest. The report is by no means unanimous. A majority report is signed by the late Earl of Iddesleigh, the able president of the commission, and eighteen of his fellows. Eleven of these, however, sign under certain restrictions and reservations, which they append over their respective signatures. The minority report, which represents the views of the so-called fair-trade party, is signed by Lord Dunraven and three others. A third report is submitted by Mr. Arthur O'Connor, and signed only by himself.

The majority report begins by mentioning the general points of agreement among all the witnesses examined. These are said to be, 1°, that the trade and industry of the country are in a condition which may fairly be described as depressed; 2°, that this depression takes the form of a diminution, and in some cases an absence, of profit, with a corresponding diminution of employment for the laboring classes; 3°, that neither the volume of trade, nor the amount of capital invested therein, has materially fallen off, though the latter has in many cases depreciated in value; and, 4°, that this depression dates from about the year 1875, and that, with the exception of a short period of prosperity enjoyed by certain branches of trade in the years 1880 to 1883, it has proceeded with tolerable uniformity, and has affected the trade and industry of the country generally, but more especially those branches which are connected with agriculture.

This unanimity did not extend, however, to the causes which brought the depression about. But those causes to which any great importance was attached were, 1°, over-production; 2°, a continuous fall of prices, caused by an appreciation of the standard of value; 3°, the effect of foreign tariffs and bounties, and the restrictive commercial policy of foreign countries in limiting English markets; 4°, foreign competition; 5°, an increase in local taxation; 6°, cheaper rates of transportation enjoyed by foreign competitors; 7°, legislation affecting the employment of labor in industrial undertakings; 8°, superior technical education of foreign workmen.

It is pointed out that it is from the employers of labor and producers that most complaints of trade-depression have come; but the report adds, that its signers are satisfied that in recent years, and particularly in the years during which the depression has prevailed, the production of commodities generally, and the accumulation of capital in the country, have been proceeding at a rate more rapid than the increase of population; and in support of this the statistics as to pauperism, education, crime, and savings banks, are cited. The statistics of foreign trade show an apparent falling-off in some respects; but this is attributed almost entirely to the continuous fall in prices, especially those of raw materials, since 1873. After making allowance for this fall in prices and for the fall in the price of raw materials, it is held that the actual products of British labor and capital have largely increased. It is pointed out, for example, that, if valued at the prices current in 1873, the aggregate of the foreign trade of Great