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ARTICLE VIII.

THE DAY OF REST IN NATURE AND HUMAN NATURE.[1]

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LABORATORY EXPERIMENTS.

THAT sustained effort of mind or body brings about a state of weariness with marked impairment of efficiency is among the commonest facts of human experience. That an adequate period of rest will abolish the weariness and restore the efficiency is knowledge that sustains the tired worker through his period of toil and enters gratefully into his experience at its completion.

These facts of common knowledge, which are, indeed, guiding principles of everyday life, become to the man of science more than just facts on which he may base his conduct; they are to him vital phenomena crying for interpretation. Confronted with the fact of human fatigue he wishes to know what are the bodily processes concerned in it; noting that rest causes weariness to disappear he seeks to learn what there is about rest to give it a power so beneficent.

No one would maintain that the nature of fatigue is wholly comprehended, yet in a general way we understand the processes concerned in it. We know that it results from activity of mind or body. We know, further, that in the production of activity the body operates as an engine, and is subject to

the same laws as govern other engines. Of these the most fundamental is the law that the energy manifested cannot be created within the engine out of nothing, but must come from an antecedent source. The body, in respect to its energy source, is a chemical engine, deriving its power of activity from chemical transformations in material obtained directly or indirectly from the food. In these chemical transformations by which energy is afforded the material does not vanish, it merely enters new combinations. These latter are without value to the body; they are waste products to be gotten rid of as speedily as possible.

The body is so constructed that the energy-yielding transformations, and the consequent production of waste substances, occur directly within the regions of exertion. The muscles that are moved are the immediate seats of the chemical processes which furnish the energy for the movements; the brain cells whose activity constitutes a mental process carry on within themselves the chemical changes upon which their activity is based. In this location of the precedent chemical activity within the operating tissues we have the clue to the nature of fatigue, for the chemical transformations inevitably give rise, as we have seen, to waste products, and as these accumulate, by virtue of their mere presence, they hamper the operation of the tissues. The familiar analogy of the furnace choked with its own ashes illustrates the situation.

With a chemical basis for fatigue thus established in the waste products of tissue activity, we are in position to pass to a consideration of the question with which we are more immediately concerned, namely, the manner in which, during rest, fatigue is overcome. Obviously if fatigue is caused by the accumulation of waste products within the active tissues it is to be overcome by their removal. The agency for re-

moval is the blood, with whose swiftly flowing stream all the active tissues are in intimate communication and to which they deliver the waste substances that accumulate within them.

If the relationship between tissues and blood were so complete that waste products could be discharged from the tissues as fast as they were formed such a condition as fatigue would apparently be non-existent. Unfortunately such a perfection of relationship does not obtain. The discharge of waste products into the blood-stream often lags behind their production. Moreover, the blood itself is likely to become charged with these substances, in situations where they are being produced abundantly by highly active tissues, through the inability of the organs of excretion to keep pace with the demands upon them. Thus fatigue, instead of being confined to the region of activity, is often carried over the whole body, and we may have the feeling of general weariness, although the exertion may have been confined to special tissues. The necessity for periods of rest alternating with periods of activity, a necessity established by immemorial human experience, is thus seen to be for the purpose of allowing time in which the accumulated waste materials may be cleared out, restoring the tissues to their initial condition of fitness.

Through this recognition of the function of rest in the overcoming of fatigue we approach the problem of the significance, from the scientific standpoint, of the regularly recurring day of rest. The question at issue is this: Are any of the bodily tissues so affected by waste products that they cannot make complete recovery during the usual daily interval of rest? If this question is answered in the negative, if there are no tissues which continue to show impairment after an ordinary rest interval, there would seem to be no scientific

basis for the practice of a weekly rest day. If, on the other hand, the question is answered in the affirmative, if any bodily tissues at the end of the usual rest period are not wholly recovered, such tissues will enter upon the next season of activity in a state of impairment. This impairment will become more and more marked as days go by, until some sort of a dead level of inefficiency is reached, unless before the cumulative impairment has gone so far as to be serious, an interval of rest, long enough to allow complete recovery, is resorted to. To determine whether or not there is cumulative fatigue in the sense here referred to is the task of the scientific investigator.

EXPERIMENTS.

The series of observations now to be described briefly were designed to test the question of cumulative fatigue and recovery with reference to the nervous system. The theory on which the investigation was based was this: Suppose an accurate test of the condition of the nervous system be applied day by day to a number of individuals over a considerable period of time. If the number of subjects is great enough and the time long enough to eliminate incidental variations, progressive fatigue, if any exists, should be shown by a steady lowering of the level of nervous ability, and recovery, where recovery occurs, by a restoration of the initial level. The test of nervous state consisted of a measurement of the sensitiveness of the subject to electric shocks, applied to a selected region of the body surface.[1] Various investigations have shown that the degree of sensitiveness to such shocks is determined chiefly by the general nervous state, so that in meas-

[1] For a detailed description of the experiments see Martin, Withington, and Putnam, American Journal of Philosophy, 1914, vol. xxxiv. p. 97.

urements of this degree of sensitiveness we have a reliable index of nervous condition.

Tests were carried on for eight weeks with nine medical students as subjects. The general conditions of the investigation were favorable inasmuch as our subjects were following a pressing intellectual routine, which occupied their waking hours fully for six days each week, and from which they had such relief on the seventh as was afforded by a complete suspension of class exercises, with the resulting marked break in routine.

When the investigation was completed and we began to study our accumulated data, the fact became at once apparent that our subjects did not maintain a constant nervous condition for any considerable period. From day to day there were fluctuations in sensitiveness sometimes in one direction and sometimes in the other, which seemed, at first view, quite adventitious. More careful scrutiny of the records showed, however, that the fluctuations followed, in the main, a very definite course. Ordinarily each day's record was lower than that of the day before. The general trend was downward. This downward trend, however, did not continue long. Presently the record would show an abrupt return of sensitiveness to the initial high point, from which high point, as day succeeded day, the trend would again be downward.

The striking and significant feature of the record is that the interval which showed the abrupt increase in sensitiveness was that from Saturday to Monday; the period of pronounced break in routine. Whereas a single night's rest did not suffice to prevent the nervous tone from showing a decline, the longer interval of Sunday not only arrested the decline, but restored the nervous system to its normal condition.

To summarize: Our experiments brought out the follow-

ing facts: From Monday to Saturday there was a tendency for the nervous tone of the subjects to diminish progressively. There were, of course, occasional departures from this tendency, but on the whole the downward trend was unmistakable. Between Saturday and Monday, on the other hand, the nervous state showed marked improvement.

That the progressive downward trend from Monday to Saturday was the result of cumulative fatigue can scarcely be doubted. That during the Sunday rest period opportunity was afforded for the complete elimination of the fatigue-producing substances seems equally clear.

These observations do not, of course, constitute a discovery, in the sense that they direct human thought into channels hitherto unfollowed. The conception that the strain upon the nervous system from a day of intellectual activity is greater than can be overcome in the rest of a single night is by no means new. It has been in the minds of men since the significance of fatigue as a factor in human efficiency first received serious consideration. In matters affecting human conduct, however, so neglectful often is man of his own welfare, we have to "make assurance doubly sure"; to heap argument upon argument. The effect of our observations is to add the weight of impartial scientific judgment to the side of the influences favoring the day of rest. If our work by any amount, however small, contributes to the advancement of right living among men we esteem it more than justified.