THE ANIMATE AND THE INANIMATE

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PREFACE

This work sets forth a theory which is speculative in nature, there being no verifying experiments. It is based on the idea of the reversibility of everything in time; that is, that every type of process has its time-image, a corresponding process which is its exact reverse with respect to time. This accounts for all physical laws but one, namely, the second law of thermodynamics. This law has been found during the nineteenth century to be a source of a great deal of difficulty. The eminent physicist, Clerk-Maxwell, in the middle of the nineteenth century, while giving a proof of that law, admitted that reversals are possible by imagining a "sorting demon" who could sort out the smaller particles, and separate the slower ones from the faster ones. This second law of thermodynamics brought in the idea of energy-level, of unavailable energy (or "entropy" as it was called by Clausius) which was constantly increasing.

In the theory herein set forth, we suppose that reversals of the second law are a regular phenomenon, and identify them with what is generally known as life. This changes the idea of unavailable energy into that of a reserve fund

of energy, used only by life, and created by non-living forces.

This is in accordance with some recent discoveries. The late Prof. William James has discovered in the domain of mental phenomena what he calls "reserve energy," which later investigation has shown to be present to a more limited extent in all biological phenomena. It remained a mystery, however, where this energy came from, and the theory of reserve energy as set forth in this work suggests a possible explanation of these phenomena.

In relation to the universe as a whole, the theory herein set forth represents the idea of what is known as cyclical change. This idea is a very old one, being found among the philosophers of the Ionian school, and reappearing at later periods from time to time. On the other hand, the generally accepted theory of the second law of thermodynamics represents a different philosophical tendency, the tendency that considers changes once made as irreparable. Aristotle's philosophy is a good example of that tendency in ancient times, but it has appeared more recently, especially in Spencer's theory of evolution, which, it is interesting to note, is hardly more than a statement of the second law of thermodynamics in philosophical terms.

Since the manuscript was completed my attention was attracted by a quotation from a lecture by the great scientist, Lord Kelvin, in which a theory is suggested which is very similar to mine in its general outlines; Lord Kelvin, however, does not work out the theory. He suggests that life works through a reversal of the second law of thermodynamics; and that living organisms, especially animal life, actually act the part of Clerk-Maxwell's "sorting demon." Lord Kelvin, however, regards this as an indication of some suspension of the ordinary physical laws, instead of seeking for the explanation of this reversal in these physical laws themselves.

To quote Lord Kelvin's own words: "It is conceivable that animal life might have the attribute of using the heat

of surrounding matter, at its natural temperature, as a source of energy for mechanical effect . . . . The influence of animal or vegetable life on matter is infinitely beyond the range of any scientific enquiry hitherto entered on. Its power of directing the motions of moving particles, in the demonstrated daily miracle of our human free-will, and in the growth of generation after generation of plants from a single seed, are infinitely different from any possible result of the fortuitous concurrence of atoms."

Here the suggestion is obvious that the phenomena of life operate as Clerk-Maxwell's supposed "sorting demon," through reversing the second law of thermodynamics and utilising the unavailable or reserve energy of matter; only Lord Kelvin, instead of deriving this from the ordinary physical laws, immediately concluded that some mysterious vital force must be in operation. Under my theory, this reversal can be explained on the pure basis of the theory of probability.

It is also to be noted that the theory which I suggest in this work solves not only the biological problem of reserve energy, but also certain astronomical paradoxes in connection with the theory of the structure of the universe and its evolution.

The latter part of the work, which deals with the theory of the reversibility of time and the psychological aspect of the second law of thermodynamics itself, is a purely speculative section, partaking more of the metaphysical than of the scientific. However, even in that section, it is to be hoped that there will be found a basis for putting the theory of the nature of time on a scientific basis and for taking it finally outside of the domain of metaphysics.

At the end of the work, a number of objections to my theory are stated in order to show what objections can be adduced. I do not attempt to answer these arguments, but, for the sake of fairness to the reader, simply state them and leave them unanswered, so that the reader may decide for himself all the pros and cons of the question, and come to a more unbiased conclusion.

At first I hesitated to publish my theory of the reversibility of the universe; but I was encouraged on discovering the quotation from Lord Kelvin above mentioned; so that now, knowing that this is not the first time that it has been suggested that life is a reversal of the second law of thermodynamics, I have decided to publish the work and give my theory to the world, to be accepted or rejected, as the case may be.

WILLIAM JAMES SIDIS

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CHAPTER ONE

THE REVERSE UNIVERSE

Among the physical laws it is a general characteristic that there is reversibility in time; that is, should the whole universe trace back the various positions that bodies in it have passed through in a given interval of time, but in the reverse order to that in which these positions actually occurred, then the universe, in this imaginary case, would still obey the same laws.

To test reversibility, we may imagine what we may call "the reverse universe," that is to say, another, an imaginary universe, in which the positions of all bodies at various moments of time are the same as in our real universe, in which those positions occur at the same respective intervals of time but in the reverse order. To assist in imagining this reverse universe, we may remind ourselves that, when we look in a mirror, the imaginary world that we see in that mirror corresponds in every detail to the world we are in, with the exception that one dimension of space occurs in the reverse order, namely the direction perpendicular to the plane of the mirror. If, now, we conceive of time as a sort of additional dimension of the universe, then our "reverse universe" would be one in which there was a similar reversal in that dimension, leaving the three dimensions of space unaltered. Or, to put it in another way, the series of images produced by running a motion-picture reel backwards would give exactly the impression of such a reverse universe.

With this auxiliary, imaginary universe, our test of the reversibility of any given physical law or process

would be, whether that law holds good, whether that process still subsists in the reverse universe. In order to see that in any case, we may first find out how to translate any physical occurrence into the corresponding occurrence in our reverse universe. To start with, all positions in space remain absolutely the same in the reverse universe as in the real universe; intervals of time, however, remain the same in magnitude but are reversed in direction. In other words, though the absolute amount of an interval of time remains unchanged, it is necessary, in translating into terms of the reverse universe, to replace "before" by "after," and vice versa.

The path of a moving body will remain the same in the reverse universe because all the positions which constitute that path will remain unchanged. Since, however, the positions are reached in the reverse order of time, the body moves along the path in the reverse direction. The absolute amount of corresponding intervals of space and time in this motion remaining unchanged, it follows that all velocities must, in the reverse universe, be the same in amount but exactly reversed in direction.

We come to a problem of greater difficulty in considering what becomes of acceleration. Acceleration is the rate of change of velocity with respect to time. If, to make the question simpler, we assume uniform acceleration, then the acceleration of a body is equal to the difference of velocity divided by the interval of time required to produce this difference. If, for example, in an interval of time T the velocity A is changed to the velocity B, the acceleration (vectorially represented) would be (B-A)/T. In the corresponding motion in the reverse universe, in the interval of time T, the velocity changes from -B to -A, so that the acceleration is [(-A)-

(-B)]/T, or (B-A)/T. In other words, the acceleration of a body remains unchanged in the reverse universe, both in amount and in direction, in translation into terms of the reverse universe. The above reason assumes that the acceleration of the body is uniform, but an extension of the same reasoning will show that the same conclusion holds even when the acceleration is constantly varying.

So much for pure kinematics. For dynamical terms, it is necessary to find what happens to the mass of bodies in the reverse universe. Now, mass being merely amount of matter, and unrelated to time, it follows that mass is not in the least changed by reversal. From that it follows, by what we have seen, that all momenta are reversed in direction but unchanged in amount, while, in the reverse universe, the force acting on a body, being the product of two magnitudes that remain unchanged in the reverse universe (namely, the mass of the body and the acceleration, assuming no other force to act), must necessarily remain unchanged in the reverse universe not only in amount but also in direction. It might have been expected that, in the reverse universe, forces would be reversed in direction; but this is not so.

Energy, being entirely dependent on such things as position and force (in the case of potential energy) or on mass and the square of speed (in the case of kinetic energy), all of which remain entirely unchanged in the reverse universe, must manifestly remain entirely unchanged.

We come, however, to a more complicated problem in the question of the causal relation. For this purpose it is necessary to distinguish various kinds of causality. The true relation of cause and effect is one of temporal sequence; e.g., the removal of the support of an object is the cause of its falling. The force of gravity has been

there all the time; and it is a logical consequence of the existence of such force that the fall of an object should follow the removal of its support. Strictly speaking, the force of gravity is in this case not a *cause*, but an *explanation*, a reason for the actual causation, which is itself merely a sequence with an explanation. We have thus to distinguish between the relation of reason and consequence, on the one hand, and, on the other hand, the relation of cause and effect. The latter implies sequence in time, the former is a pure relation of logical deduction and essentially implies simultaneity, for the reason and the consequence, one being a logical deduction from the other, must both subsist together.

Now, in the reverse universe, we must suppose that all logical relations of facts remain the same. This does not imply anything concerning mental phenomena; of that we shall find out later in our investigation. In fact, logical relations of facts must of necessity subsist apart from the question whether or not a mind exists in the universe. Logical relations may be said to be simply the most general external facts in existence. If A is B and B is C, the rule then is, not that I think that A is C; it is a fact verifiable by observation that A is C. Hence, even should the reverse universe destroy completely all mental phenomena, logical relations must remain unchanged, and consequently also the relation of reason and consequence.

But with true physical causality, it is otherwise. If some general law or some particular force resulting therefrom has for its consequence, in the real universe, that event A should be followed by event B, then the corresponding law or, force in the reverse universe must result in the corresponding events A' and B' following one another in the reverse order. That is to say, if one physical event causes another in the real universe, then

the event corresponding in the reverse universe to the effect will, in general, cause the event corresponding in the reverse universe to the cause. That is to say, in translating into terms of the reverse universe, "cause" is to be translated by "effect," and vice versa. This, however, is not an accurate rule, there being exceptions, a causal relation being sometimes altogether severed or else unrecognizably altered by the reversal of time.

Again in the reverse universe, such properties as density, specific heat, elasticity, amount of heat, temperature, etc., also remain unchanged. It could also be shown that such properties as electricity and magnetism remain unchanged, but that the direction of an electric current would be reversed. Thus all physical phenomena could readily be translated into terms of the reverse universe. The various varieties of substance, depending on the internal structure of the atom and molecule, etc., also remain unchanged in the reverse universe.

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CHAPTER II

REVERSIBLE LAWS

Now we shall attempt to find out what are the physical laws which subsist in this imaginary "reverse universe." To start with the simple laws of mechanics, we have it given in the real universe that a body retains its velocity unless there is some external force to change that velocity. Now, as there can be no change of velocity in the reverse universe without a corresponding change of the reverse velocity in the real universe, and since all forces in both universes are respectively equal, it follows that this same law of motion applies also in the reverse universe. In other words, the law of inertia is unchanged by the reversal in time, and is therefore what we may call a *reversible* physical law.

The second law of motion is that change of momentum is proportional to force impressed. Now, following the reasoning which we have already followed in the case of accelerations, the rate of change