

stable distribution of infinite standard deviation, already encountered by P. Lévy in his work on normal stochastic processes.

NORBERT WIENER

Massachusetts Institute of
Technology.

AUREL WINTNER

The Johns Hopkins
University.

¹ Wiener, N., "The Fourier Integral and Certain of its Applications", Chapter 4 (Camb. Univ. Press, 1933). For further developments, cf. Wiener, N., and Wintner, A., *J. Math. and Phys. (M.I.T.)*, 17, 233 (1939); and Wiener, N., and Wintner, A., *Amer. J. Math.*, 63, 796 (1941).

² Wiener, N., *Acta Math.*, 55, 117 (1930).

³ Birkhoff, G. D., *Proc. U.S. Nat. Acad. Sci.*, 17, 650 (1931).

⁴ Lévy, P., *Compositio Math.*, 7, 283 (1939).

Contraction of Time and Protoplasm

IN recent discussions concerning the clock paradox, biological time is mentioned but dismissed as of little consequence in the matter¹. Contrary to this view and regardless of the solution finally found acceptable in the clock paradox, the entire problem really centres in biological time. Whether we accept or reject a completely mechanistic view of protoplasmic processes and therein compare them to an actual clock in the sense of their mechanical workings, or believe in other processes, in addition to the mechanistic view, the statement that biological time is the centre of the matter still holds. No one has ever shown that biological processes are identical in their functional attributes to the mechanical universe envisaged by the physicists. If biological time is not identical to the physicists' time then asymmetrical ageing is meaningless, so far as biological phenomena are concerned. One of the most outstanding physicists, upon analysing the meaning of life, gives an opposite view. Schrödinger² states: "from all that we have learnt about the structure of living matter we must be prepared to find it working in a manner that cannot be reduced to the ordinary laws of physics". I take it from this statement, and my own experience of more than twenty-five years of working with living materials, that the laws which control protoplasm are of a different order of integration from those of ordinary physics. This is not surprising in view of its functional complexity.

If we admit the postulates of the relativity theory apply to time-space factors, using a mechanical clock to reveal the asymmetry of the result, this is one thing; if we use a human or other living organism to reveal the result, the effects may predictably be an entirely different matter. The space-time dilatation is most profoundly related to biological processes in two obvious aspects: (1) all primary data upon which the concept is based are biologically sensorially derived; (2) if time-space factors are to show asymmetrical age differences in the stay-at-home versus the space traveller, then the biological processes of growth and ageing are involved.

Aspect (1), of course, looks directly into the whole problem of reality and causality. If as Russell³ and others think, namely, that causality originates in perception, we can scarcely escape the implication of this in our reasoning about time dilatation and biological time. The two are closely linked. While the final status of biological time is probably in as confused a state⁴ as is the clock paradox, we can, in a

sense, deal with it in a more direct experimental manner.

The involvement of biological factors of ageing and growth processes in the relativistic contraction of time is very real. Biological matter has to exist not only in a physical inertial frame, of some sort, but also in some kind of time continuum. The problem here is whether or not biological material (protoplasm to be specific) is in any way affected as a function of velocity, or if it is affected in any way, or if the narrow bios zone which is an absolute necessity for survival of protoplasm also includes absolute velocity. (The discussion disregards acceleration, deceleration effects upon the intact animal which are in part understood.)

McCrea⁵ mentions biological time but denies its importance through the route of making the difference between biological time and clock time arbitrarily small. He says that biological processes need not be standardized with a standard clock accompanying the system. This is the heart of the problem: is not our entire interpretation of time sense biologically conditioned? The question must be asked whether all the biological processes depend upon rate of travel of protoplasm. The supposition is that growth processes will be retarded or actually reversed, yet everything we know about protoplasmic processes denies that this is possible. Living processes may be temporarily suspended under certain conditions, or slowed down, but the range of this is extremely narrow. Since all other factors, which maintain protoplasmic integrity, are of a narrow limited range, may not the same be true of the function of velocity? The interesting thing is that it does not seem to have occurred to anyone that experiments might well be performed in this connexion.

The implication in the work on asymmetric ageing is astounding since the physicists predict that increased velocity will slow up or reverse what are major biological functions, namely, the ageing and growth functions. It is as though they believe both of these are simply physical models of systems identical in final analysis to a clock. Without getting into the idea of entelechy, it suffices to state that while we may accept the physicist's view of biological materials we cannot deny that the order of organization of protoplasmic processes may be such that the ultimate upper integrative level of biological processes may function in a manner entirely different from the materials thus far tested on the electron-proton level.

Taking the other facet of the argument, assuming that the physicists are correct, and that growth and ageing processes are connected with velocity in the fashion they assume, it would be of extreme importance to determine this, since by utilization of the velocity factor we could modify living processes almost at will. Again an experimental approach is called for in order to secure the answer.

ANDERSON NETTLESHIP

Medical Center,
University of Arkansas,
Little Rock.

¹ Dingle, H., *Nature*, 177, 782, 785 (1956); 178, 680 (1956); 179, 865, 1242 (1957).

² Schrödinger, E., "What is Life?" (Cambridge Univ. Press, 1951).

³ Russell, Bertrand, "The Analysis of Matter" (Dover Pub. Inc., New York, 1954).

⁴ Du Nouy, Le Comte, "Biological Time" (Methuen and Co., Ltd., 1936).

⁵ McCrea, W. H., *Nature*, 179, 909 (1957).