be drawn: (a) The particulate-containing fractions were the only ones in which the PPDA oxidation was markedly stimulated by the addition of cytochrome C in both mutant and normal tissues. (b) The same fractions were the only ones markedly inhibited after addition of azide. (c) Catechol was oxidized by normal tissue fractions at a much higher rate than by the fractions from mutant tissues. (d) The supernatant fraction showed considerable oxygen uptake in the presence of PPDA. This, however, did not involve the cytochrome system, as the addition of neither cytochrome C nor azide had any marked effect on the rate of oxidation.

TABLE 2

RANGE IN ENZYMIC ACTIVITIES OF ISOLATED PLASTIDS AND MITOCHONDRIA FROM NORMAL AND VARIEGATED LEAVES OF *Nicotiana tabacum**

Plastids	PPDA	PPDA + cyto-chrome C	Catechol	Endo-genous
Normal	0.1	2.7	14.1	.5
plastids	2.1	4.1	29.5	.2
	4.0	10.0	...	1.0
Normal	2.0	3.7	13.7	.4
mitochondria	2.6	5.9	18.1	.2
Mutant	2.6	6.8	3.7	0
plastids	1.8	11.2	0	.3
	2.7	11.9	...	.3
Mutant	2.4	7.5	3.1	0
mitochondria	4.1	21.6	0	1.4

* Each horizontal row represents data from one experiment. All activities are expressed as µl O_2 consumed per mg dry wt per hr and are based on duplicate determinations.

In general, the results obtained with *Nicotiana* and *Lonicera* show that both mitochondria and plastids carry all or the bulk of the cytochrome oxidase activity of the cell, thus providing further evidence for the homologous nature of plant and animal mitochondria. Furthermore, the data from *Nicotiana* demonstrate that mitochondrial mutation can result in marked derangement of certain enzyme systems of the cell, and that such abnormalities are apparent in both mitochondria and plastids.

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The Significance of Nonclassical Statistics

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Certain statements by Wiener (*3*) have led to the considerations given here, regarding the conditions under which the Gibbs type of statistics are and are not convenient for describing Newtonian systems. A parallel is traced between this situation and that which is met in wave mechanics, and the conclusion is reached that the success of nonclassical statistics in wave mechanics is not in itself evidence that atomic systems are not Newtonian.

The first statement, p. 110, is:

> In the Newtonian physics, the sequence of physical phenomena is completely determined by its past, and in particular, by the determinations of all positions and momenta at any one moment. In the complete Gibbsian theory it is still true that with a perfect determination of the multiple time series of the whole universe, the knowledge of all positions and momenta at any one moment would determine the entire future. It is only because these are ignored, nonobserved coordinates and momenta that the time series with which we actually work take on the sort of mixing property with which we have become familiar in this chapter, in the case of time series derived from the Brownian motion.

Then at the bottom of p. 117:

> . . . a dynamical system with no input may go into permanent oscillation, or even oscillation building up to infinity, with an undetermined amplitude. In such a case the future of the system is not determined by the past, . . .

Such a system obviously does not conform to the definition of a Newtonian system given in the first quotation. Since Wiener is presumably referring to macroscopic systems, the individual parts of which obey Newtonian laws, his statement implies that a non-Newtonian system may be constructed from Newtonian parts. We are therefore led to question the existence of a system such as he describes.

Certainly some systems which are capable of sustained oscillations do not go into that condition "with no input." A pendulum clock or a gasoline engine requires a starting input comparable in magnitude with the resulting oscillations. Certain types of vacuum tube oscillator, which depend on exact relations among the harmonics, will not oscillate for certain circuit adjustments unless they are subject to a fairly large input disturbance. By suitable design the magnitude of the required input may be reduced to the point where it is practically impossible to bring the system into a condition suitable for oscillations without having them start. Here the starting input may be of either of two forms. It may be a by-product of the adjustment which sets up the oscillatory condition. Here it is obviously determined by the past and nothing non-Newtonian is involved. If we assume that the system can be brought into a condition of unstable equilibrium and left there, then it will remain in that state indefinitely unless it is disturbed by some input. Because of the regenerative amplification which accompanies this condition, an exceedingly small input will suffice to start the oscillations. However, because the build-up occurs at a finite rate, an infinitesimal input will not become finite in any finite time. Hence a finite though small input is required and the future does depend on the past, particularly as regards the phase of the oscillations.

Thus we conclude that the second quotation is never literally true. However, the nature of the connection between past and future for certain oscillators is so different from that for ordinary mechanical systems that they warrant special consideration, particularly with reference to statistical treatments.

For purposes of comparison consider the case, discussed by Wiener, of signals disturbed by noise due to Brownian movements. When the differences between the various signals are very large as compared with the average noise, then—except on rare occasions when the instantaneous noise is very much greater than its average—the presence of the noise may be ignored. The present of the system, to the degree of accuracy in which we are interested, then appears to be completely determined by the past as represented by the signals sent. If now we reduce the signals to a size comparable with the Brownian motions, this is no longer true. As stated in the first quotation, the basic assumptions of Gibbs still hold, that were the actual values of all the positions and momenta included, the present would be uniquely determined. Statistical uncertainties arise only because we choose to ignore the values of certain quantities, the existence of which we recognize. As a result the changes to be expected are at all times subject to statistical prediction only.

Contrast with this the behavior of an ensemble which includes a large number of oscillators the startings and stoppings of which are caused by disturbances which are extremely small as compared with the oscillations. A watch with some dust in its works would be started or stopped by a very small displacement of a dust particle. Once started or stopped its behavior would appear to be independent of the exact position of the particle. Suppose now we observe a large rackful of such watches under such quiet conditions that no dust particles move sufficiently to cause any watch to undergo a transition from one state of oscillation to another. They all appear to function as Newtonian systems in which all motions are accounted for and the present is completely determined by the past.

Now let the rack be loaded on a truck and driven over a moderately rough road so that the dust particles are agitated. The various watches will then be found to start and stop in an erratic fashion. The system is still Newtonian, however, and if we choose to ignore the positions and momenta of the various parts of the truck and of the dust particles, it should still be possible in theory to formulate a Gibbsian statistical treatment of the behavior of the recognized coordinates and momenta—namely, those of the watches.

Comparing this situation with that of the Brownian noise, we find an important difference. In the latter case the quantities, the values of which are ignored, produce an appreciable change in the time function of the signal at all times. In the case of the watches, however, their behavior is essentially independent of the motions of the dust particles except at widely spaced intervals of extremely short length when the transitions occur. This suggests that it should be possible to construct a statistical treatment of the behavior of the watches in which we not only ignore the values of the positions and momenta of the dust particles but also ignore their existence during those periods when they do not influence the watches appreciably. The result is a system in which each watch conforms to Newtonian laws between transitions and the times of transitions are indeterminate except that as a whole they conform to some statistical law. In setting up this system we have, for the time functions of each dust particle, broken what Wiener calls its "determinate thread of development in time." The present of the system is no longer determined by its past, and the new statistical description does not conform to the basic requirements of Gibbs.

We are thus led to the conclusion that in Newtonian systems which involve transitions of oscillators between oscillating and nonoscillating states, it may be more convenient to describe certain features of the system's behavior statistically in terms of a system which is not of the Gibbsian type than of one that is. It follows from this that the mere fact that a system involving such transitions can be conveniently described in terms of non-Gibbsian statistics does not constitute evidence that the system is not Newtonian.

So far we have assumed that the required disturbances are all very small. What happens when some or all of the oscillators are relatively stable, in the sense that they require a considerable disturbance to produce a transition? It might appear at first sight that if these are to be affected at all, the disturbance must be so large that it cannot be neglected between transitions. This is not the case, however, if the disturbance is of a random nature. Its average value may then be small enough to be neglected between transitions, and yet it will on occasion take on values great enough to start any particular oscillator. The probability of such a transition will of course decrease very rapidly as the required disturbance increases. It may still be possible, therefore, to ignore the random disturbances except as they affect the transitions.

Before taking up the parallel between this situation and that which exists in wave mechanics, attention should be called to a type of Newtonian oscillator (*1, 2*) which has received relatively little consideration, but which is suggestive of the transitions of atomic theory. A system involving a nonlinear stiffness or inertia may "go into permanent oscillation," in which energy from an alternating source is converted into oscillations at two lower frequencies which are connected to that of the source by the usual quantum relations. For a nonlinear stiffness, the energy divides in the ratio of the frequencies. If we think of an excited state of an atom as the source, and the ground state and emitted radiation as the two oscillations which appear when the system goes into oscillation, the parallel is evident. Here, as for the familiar oscillator, a threshold condition exists, and once it is satisfied the starting of the new oscillations, and their phases, are dependent on some disturbance, however small.

If, then, it were found possible to describe atomic transitions as the initiations of oscillations of this type in a Newtonian system, the associated disturbances might produce significant effects only at the transitions. Their effect could then be adequately taken into account by assigning probabilities to the transitions and treating the system as non-Newtonian. (This of course leaves open the question as to whether the behavior of the system between transitions can be described in Newtonian terms.)

Recently, however, it has been found desirable to assume the existence of a randomly fluctuating electromagnetic field in free space, of such magnitude as to produce a small but not negligible effect on the behavior of the elementary particles. Such a field would be precisely what was assumed in the previous paragraph, and should provide a mechanism for controlling the apparently random transitions.

We arrive then at the conclusion that the fact that it has been found convenient to describe atomic phenomena in terms of a non-Newtonian system characterized by certain probabilities of transitions does not in itself constitute evidence that the system in its detailed behavior does not conform to Newtonian laws.

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An Analysis of Multiple Counter Technique for the Measurement of Radioactive Sources Independent of Geometry

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This discussion is concerned with the mathematics of a system of multiple Geiger-Müller counters for the measurement of radiations from a point source within the area bounded by the counters. Graphs are presented from which an area giving any desired accuracy of measurement can be determined.

Similar multiple counter techniques (*1, 2*) have been used by others over the past several years and offer considerable promise for precise physical, medical, and biological measurement.

A sketch of the apparatus is given in Fig. 1.

For the purpose of analysis the following assumptions are made regarding the geometry, source, and counters.

[1] The authors wish to acknowledge the counsel, during discussions, of Dr. A. K. Solomon, Biophysics Laboratory, Harvard Medical School. They also wish to acknowledge the work of P. J. Edwards, who performed the computations.

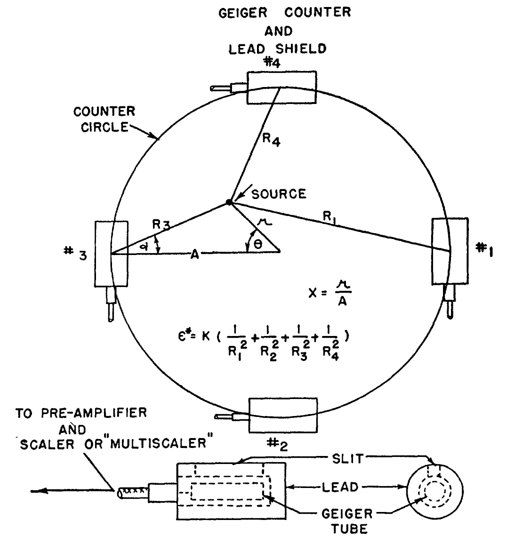

FIG. 1. Sketch of multicounter and lead shield.

1. The radiation is emitted uniformly in all directions about the source. There is no absorption in the medium between the source and counters; or the absorption is uniform in all directions.
2. The efficiency of the counter is proportional to the solid angle subtended at the source by the Geiger counter cathode, and the solid angle is inversely proportional to R^2, where R is the distance from the source to the center of the counter cathode.
3. The efficiency of the counter is independent of angle α between the normal to the counter cathode and the line from the source to the center of the cathode.
4. All counters have identical counting characteristics (plateau and efficiency).
5. The source is a point.
6. The region of interest is limited to the plane containing the centers of the four counters.

Under these assumptions the analysis is reduced to eval-

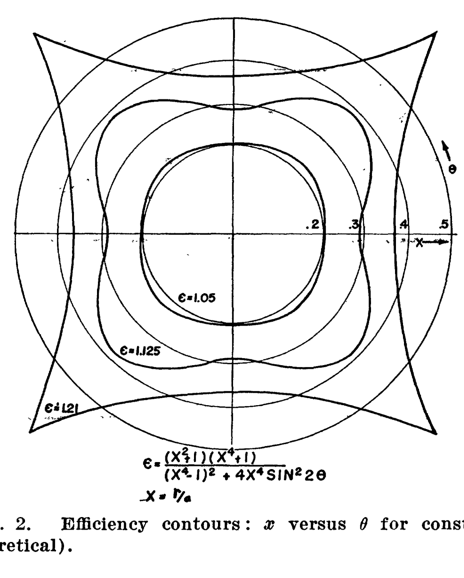

FIG. 2. Efficiency contours: x versus θ for constant ε (theoretical).