lines of N 30 W. In the area west and northwest of Lake Okeechobee the lagoons and probably sand ridges were arranged along lines of N 45 W. Southwest and west of Miami the lines were arranged in broad sweeping curves convexed toward the east, approximating the curve of the Florida Keys.

The impression produced was very striking. The probable explanation is that this arrangement is due to currents, or currents and winds acting together during Pleistocene time, when all of this portion of Florida was covered by shallow sea.

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THE USE OF THE TERMS POLYGAMY, POLYGYNY AND POLYANDRY

THE term polygamy is frequently used as a synonym of polygyny in zoological writings. Polygamy, however, is an inclusive term, referring to the custom of having more than one mate, and includes both polygyny and polyandry. Since there is a definite meaning and a need for each of the three terms, it seems most desirable to stop the degradation of meaning and use the terms as defined in Webster's New International Dictionary, 1935:

Polygamy. The custom or practice of having a plurality of wives or husbands at the same time.

Polygyny. The mating of one male with several females, in certain animals, as fur seals.

Polyandry. The possession by a woman of more than one husband or mate at the same time.

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SCIENTIFIC BOOKS

STATISTICAL MECHANICS

The Principle of Statistical Mechanics. By RICHARD C. TOLMAN. Oxford University Press, 1939.

THIS new book of Tolman will be welcomed by every one interested in the fascinating field of statistical mechanics. Since an earlier book by Professor Tolman on the same subject, in the reviewer's opinion, remains one of the best introductory texts, one knew what to expect. The new book, however, far from being in any way a new edition of the older work, has a completely different character. Its purpose is to elucidate in detail the principles of the subject, especially in so far as they have been influenced by the development of the quantum mechanics. Except in the book of Von Neumann (which lies beyond the mathematical horizon of most physicists), this task had never been attempted. And this attempt alone makes it an important and useful book. In fact, it seems a pity that Tolman has not restricted himself to this sole task. In addition his book contains a straightforward text of the quantum mechanics (Chapter VII) and a discussion of the usual kind of applications (in Chapters X and XIV). These sections could have been omitted without loss to the main argument. They are quite satisfactory in themselves, but they are addressed, so to speak, to a different audience from that of the rest of the book.

The main part of the book may very well be compared with the famous article by P. and T. Ehrenfest in the "Enzyclopädie der Mathematischen Wissenschaften." There the principles of statistical mechanics were analyzed on the basis of the classical mechanics. Ehrenfest was able to show that many additional assumptions had to be made in order to explain the second law of thermodynamics. The clarity of his exposition has had a strong influence on the further development of the subject. And before going any further it may be said that Tolman's book reaches the same high standard of lucid and careful exposition. The two treatments of course exhibit several differences. The most important one is the difference in attitude with regard to the work of Gibbs. Ehrenfest has always held the opinion that Gibbs had only simplified and systematized the ideas of Boltzmann. Tolman, on the other hand, considers the Gibbsean concept of the canonical (and grand-canonical) ensemble as absolutely fundamental. He of course admits that for its justification one has to make certain assumptions, but he considers these as inherent to any kind of statistical approach. Furthermore, he tries to show that essentially the *same* assumption (the hypothesis of equal *a priori* probalities) has to be made in the classical as in the quantum statistics. The close analogies which exist between these two fields are very striking indeed. Tolman has emphasized these analogies by making the part of the book devoted to the classical statistics (Chapters III till VI) completely parallel to the part dealing with the quantum statistics (Chapters IX till XII). Even the wording is sometimes almost the same. Both parts culminate in the discussion of the H-theorem, which is thus given the central position it deserves.

All this surely is very illuminating. However, the reviewer must admit that the analysis of Tolman has not quite convinced him of the validity of the Gibbsean point of view, although as an old pupil of Ehrenfest, he may perhaps be prejudiced.

Since this is not the place for a detailed discussion, the reviewer will try to express in general terms his objections or perhaps better his feelings of discomfort. It is clear that the main difficulty lies in the explanation of the time-dependent processes in statistical physics. In fact, the fundamental problem is always to reconcile the reversible laws of mechancis with the apparent irreversibility of most of the phenomena which occur in nature. With regard to the theory of the properties of matter in equilibrium, there is in practice no difference of opinion. There are different ways of interpreting and justifying the canonical ensemble. But they all lead to the same general method for calculating the thermodynamic properties of a system, when the molecular constitution and the laws of interaction between the molecules are known. Of course this general method can not usually be carried out because of the great mathematical difficulties. And it is therefore perhaps not *quite* sure whether all the equilibrium properties can in principle be explained in this fashion. There is, for instance, the question of the existence of different phases of the same substance and the corresponding problem of the phase transitions, like condensation and melting. There are only the beginnings of an understanding of the liquid state. And so one can go on; the strict theory of all these matters, starting from first principles, is still lacking, although several interesting attempts have been made. Tolman does not consider these questions. Their critical discussion would doubtless have increased the book beyond all measure. They should have perhaps been mentioned at least, because they are (or better should be) essential applications of the general methods, describing the properties of systems in the equilibrium state.

However, as said before, the main difficulties lie in the explanation of the phenomena in systems *not* in the equilibrium state. And the first problem is to show that the equilibrium state, as described by the canonical ensemble, is always reached in time. This is what the x-theorem tries to do, and it is here that the differences of opinion occur. One has to distinguish between the original H-theorem of Boltzmann, which only holds for ideal gases, and the generalized H-theorem of Gibbs, which deals with the ensemble for an arbitrary system. The proofs for these two theorems have quite a different character. For gases one can actually write down an expression for the rate of change of the function H, so that one not only shows that the equilibrium state is always reached in time, but one has also an idea how long it will take. One can estimate the relaxation time. In the background, so to speak, there is also the exact theory of the transport phenomena (heat conduction, diffusion, etc.), which gives a satisfactory explanation of at least some of the non-equilibrium phenomena in gases. The situation is quite different for other systems, as in the cases of liquids and solids. Even if one is convinced by Gibbs's proof that the equilibrium state is always reached in time—and the analysis of Tolman has made the proof really quite convincing—still one has no way of estimating the relaxation time. As a result, there does not exist a strict theory, say, for the viscosity of a liquid, and in the reviewer's opinion this is *not* only due to mathematical difficulties, but it is even not clear how to formulate the problem mathematically, supposing always that the molecular constitution of the liquid and the interaction laws between the molecules are known.

This is really the main reason why the reviewer feels dissatisfied with the treatment of Gibbs and Tolman. Ehrenfest used to say that the book of Gibbs was too "smooth"; that it gave too much the impression that all problems in statistical physics were in principle solved when one could believe the classical mechanics. And the same kind of impression may be gotten from Tolman's book. This, of course, does not detract from its value. But it is the reason why the reviewer has tried to emphasize the questions which still remain open. Statistical physics has been rather neglected by the theoretical physicists, and only the simple problems have really been solved.

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SPECIAL ARTICLES

THE AUTONOMIC BASIS OF EMOTION[1]

CANNON[2] has stressed the significance of the sympathetico-adrenal discharge in emotion in a number of important papers. He attributes less significance to discharges via the parasympathetic system, although he admits that under conditions of great fear signs of parasympathetic discharge may be present together with the well-known sympathetico-adrenal syndrome. This latter phenomenon he explains by a lack of "orderliness of central arrangement" so that the "opposed innervations no longer discharge reciprocally but simultaneously and then the stronger member of the pair prevails." Several authors (Kling,[3] Bekhterev,[4] Bergmann[5] and others) have shown that, at least in the

[1] Aided by a grant from the John and Mary R. Markle Foundation.

[2] W. B. Cannon, "Bodily Changes in Pain, Hunger, Fear and Rage," New York, 1929; and "The Wisdom of the Body," New York, 1939.

[3] C. Kling, *Psychological Review*, 40: 368, 1933.

[4] V. M. Bekhterev, "Feelings and Emotions." Edited by M. L. Reymert, Clark University Press 1928, p. 270.

[5] G. Von Bergmann, Funktionelle Pathologie, Berlin, 1936.