it shall be changed, however, and there does not seem to be general agreement whether the next younger valid name based on another genus of the family and already in family form should be used, or whether the new name of the oldest or the type genus should be given a family suffix. It would seem desirable to introduce some uniformity of procedure. For example, if the generic name *A-us* 1850, the type genus of the family A-idae 1850, is found to be a synonym of *B-us* 1840, should A-idae be replaced by a newly coined family name, B-idae, in preference to an already proposed name, C-idae 1860, founded on *C-us* 1860, if *C-us* is clearly a member of the same family as *A-us*? And if B-idae should be used in this case, if *A-us* 1850 must be discarded as a newly recognized homonyn and is replaced by *B-us* 1930, should B-idae be the family name? It seems simpler and more consistent with the underlying principles of nomenclature to use C-idae in either case.

The one rule specifically applying to names above family rank is that they shall be uninomial. There seems to be general agreement that although it is desirable to use the older of two synonyms, other things being equal, it is not absolutely essential, if usage has established the later name. For example, Rodentia Smith 1827 is generally used in preference to Glires Linné 1758, and Carnivora Latreille 1825 instead of Ferae Linné 1758. There can be no serious ambiguity in the use of a better-known synonym of later date, but the situation is decidedly different if a homonym is used. The International Rules condemn homonyms for generic and specific names, explicitly and unreservedly. It would seem as if the grounds were equally cogent for the larger groups. To give specific examples, the name Cyclostomata Busk 1852 for a bryozoan order is an exact homonym of Cyclostomata Müller 1834 (= Cyclostoma Rafinesque 1815, also Cyclostoma Latreille 1829, preoccupied by Cyclostoma Lamarck 1801), the lampreys and their relatives. Decapoda Leach 1817, as a subdivision of the cephalopod mollusks, is preoccupied by Decapoda Latreille 1806 in the Crustacea. Tardigrada Illiger 1811 for the tree sloths has precedence over Tardigrada for the waterbears, a Latinization of "Tardigrades" Doyère 1840 (from "le tardigrade" of Spallanzani). In some cases the French form was in use earlier than the date given, but in no case could it reverse the technical priority, as not in Latinized form, nor does it reverse the essential priority, unless, by a stretch of the imagination in the case of "le tardigrade," which is used in the singular referring to an individual and not as a group name. In the case of "Cyclostomata" and "Decapoda," the earlier usage is quite certainly more wide-spread than the later homonym; this is probably not the case with "Tardigrada." In any case, the use of the identical name for entirely distinct groups, besides being slovenly, is a source of possible confusion, especially in bibliographic work. It would seem desirable to discontinue the use of the later term, replacing it with the earliest or best-known valid synonym (for example, Tubuliporina Milne Edwards for Cyclostomata Busk), or if none is available, by a new term.

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THE ORIGIN OF SYMPHORICARPUS

IN a paper entitled "Chromosomes and Phylogeny in Caprifoliaceae," by Karl Sax and D. A. Kribs, published in the *Journal* of the Arnold Arboretum,[1] the authors point out that the genus *Symphoricarpus* is represented in China by only one species, of very limited distribution, whereas the other species are, all of them, natives of North America. Since most of the genera of Caprifoliaceae are most abundant in Asia, and certain genera are found only in China, "it would seem probable," they say, "that the family is of Asiatic origin."

On this assumption they ask the question, "Does this mean that the genus is so old that the original Oriental forms have disappeared and only the newer American species remain?"

Is it necessary to assume that there was ever more than one species of the genus in China? Alternatively may there not have been in North America a species (allied to or even conspecific with the Chinese species and coeval with it) which died out, perhaps through climatic changes? This hypothetical species, now defunct, may first have produced offspring some of which were better adapted to the American climate. By isolation, or otherwise, such species might, conceivably, have given rise to the fifteen (or so) existing American species, which may not all be of equal age.

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ENTROPY AND ORGANIZATION

THE growth of physical concepts depends on the conditions under which they arise. As the context of ideas and experimental facts changes, these concepts also change. From this point of view, it is easy to see how the physical or mathematical probability of an event depends on the assumptions or conventions under which it is calculated. Further,

[1] *Journal* of the Arnold Arboretum, Harvard University, 11 (No. 3): 147–153, July, 1930.

probability depends on the extent of our knowledge of the phenomena in question. This fact has been brought clearly to our attention in the formulation of new statistics by Bose and Einstein, Fermi and Dirac, but has also been pointed out recently in general terms, by Lotka, Eddington and Fry. For definiteness we shall, in what follows, think of the probability of a state as the fraction of the total time of observation in which this specified state is realized. However, such limitation is not necessary for our reasoning, which depends solely on the nature of the mathematical probability.

Though this arbitrary nature of the probability concept has been repeatedly commented on, it does not seem to have been sufficiently emphasized that entropy, being derivable from probability by the Boltzmann formula, is to the same degree indefinite or a matter of convention.

Probability is always "probability-in-the-light-of-certain-kinds-of-facts," those facts, for the physicist, being chosen with reference to energy availability. In a paper at present in course of preparation it is proposed to remove this limitation from the ideas of probability and of entropy and thus permit the extension of these concepts (if necessary, under different names) to aspects of biology and psychology in which the purely physical method of abstraction may not be entirely adequate. Entropy enables us to deal with the organization of inorganic systems but provides a very crude measure for the kind of organization found in living cells and organisms. The use of available energy to produce mechanical work is only one of the activities for which living systems are organized—and not necessarily the most important. By modifying the basis on which our probability is calculated we arrive at a more catholic interpretation of "entropy" by which we can avoid the error of confining our attention only to those aspects of the organism susceptible to analysis by the methods already found successful in much less highly organized matter.

It is suggested therefore that a differentiation be made between the thermodynamic "order" or "disorder" which are measured by classical entropy, and an "organization" or "disorganization" which do not ignore the physiological or psychological features of a given situation and which take account of them in the calculation of the probability.

That there is, in thermodynamics, always an infinite number of expressions homologous with entropy has been pointed out recently by H. J. Brennen, of Northwestern University. We have, in the past, chosen the simplest integrating factor $(\frac{1}{RT})$ for the equation of state of a perfect gas, and thus the entropy obtained is the simplest of these expressions. There is, however, no reason to suppose that nature is interested only in the simplest. Thus, even in the field of thermodynamics itself, there is an arbitrariness about entropy that parallels the above statistical considerations. As this equation has been set up on the basis of purely physical observations the entropies obtained can be measures only of "order" as defined above and not of the more general "organization."

One consequence of this point of view is a realization that the amount of internal energy in a system *actually transformed into work* depends not only on the entropy of the physicist but is subject to the interference of mechanisms, lifeless or living, and of intelligence. Maxwell's demon is the abstract prototype of such mechanisms, which we may call "selecting" mechanisms. They are divisible into two classes according to whether or not they may violate the second law. From the point of view of classical entropy, only the fictitious demon (which bases its action on observations of the microscopic state) can reverse the second law or increase the "order." The other ("valve") mechanisms, which depend for their action on the value of a macroscopic variable, may control the rate at which entropy increases or—more important for the present argument—determine whether or not the available energy will be used at all. Without deciding whether or not the latter mechanisms can interfere with the second law, it is surely desirable to recognize their existence and power to affect the probability and therefore to determine the fate of the energy. There can be no question that they control the more general "organization" of which we have talked.

These ideas throw some light on the so-called "thermodynamic improbability" of the origin and continuous functioning of living organisms. Such systems are improbable only in so far as we are unaware of all the factors operative, including the factors which "emerge" within the system at higher levels of organization in virtue of that organization. The apparent improbability of the organization found in biological structures is duplicated, on a lower level, in simpler systems. For instance, colloid, crystal and surface formations often present a disconcerting degree of organization for which, however, physical chemistry has no terminology at present. This can arise only from the action of the fields of force of the molecules themselves ("selecting mechanisms" for our purpose) and complexity is possible whenever they have free interaction. Such mechanisms can produce this order only at the expense of decrease of order elsewhere in the system. On the other hand, a biological mechanism can influence the "organization" of matter foreign to itself and therefore may affect the "generalized" entropy.

These considerations are even more striking if the organism acts on the environment by way of its intelligence. Thought interferes with the probability of events, and, in the long run therefore, with entropy. The reason that this fact has escaped the physical analysis is that the physicist intentionally ignores organization which is not primarily organization for energy-availability and admits, further, available energy only in the sense of "available, if we care to, or are clever enough to, apply it for the performance of mechanical work." Actually such energy is available only if suitable mechanisms or intelligence intervene.

The idea of this note and projected paper is to relegate availability of energy to a place compatible with its biological and psychological significance.

I wish to thank Professor K. F. Herzfeld, of the Johns Hopkins, for his great help in the clarification and formulation of my argument and for his criticisms of the present note.

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SPECIAL CORRESPONDENCE

RESEARCH WORK OF THE MICHIGAN COLLEGE OF MINING AND TECHNOLOGY

THE departments of physics, geology and electrical engineering of the Michigan College of Mining and Technology are cooperating this summer in continuing the study of the electrical resistibility of various rock formations in the iron and copper districts of Michigan. The work is a part of the general research program of President W. O. Hotchkiss to concentrate research at the college along lines which will be of greatest assistance to the mining industries of the state.

The object of the research studies is to obtain more intimate geological information concerning the districts. This information will be of value in directing exploration in the future.

Professors James Fisher, C. George Stipe, John M. Gaffney and William Longacre and a corps of student assistants of the physics department are studying the electrical resistibility of various formations in the field. This work is being carried on in the region close to the college where conditions are fairly accurately known, but it is planned to extend the research into the iron country. Present indications are that by this method it will be possible in many locations to determine the depth of the water table without drilling. It appears that different kinds of rocks possess different properties of electrical resistivities, and so it is possible by this method to determine geological formations which are covered to a considerable extent with glacial deposits.

In coordination with the work being done by the physics department in the field, Professors Fay L. Partlo, John M. Harrington and T. C. Sermon are in Madison, Wisconsin, doing graduate work in physics for advanced degrees at the University of Wisconsin. They are carrying on research investigations in connection with the physics of rock formations in the upper peninsula which will fit in with the general geophysical research work being carried on at the college. One of the problems which they are studying is the magnetic permeability of different rocks. This study is undertaken to get scientific facts underlying the striking variation in magnetic attractions being used in mapping the geology of the various districts.

Professor C. O. Swanson, Joseph L. Adler and Vincent L. Ayres, of the geology department, are engaged in field geological studies in the iron districts. This work has been going on for the past two years and considerable new information regarding the geological structure and currents in the iron formations has been obtained.

Professor Wyllys A. Seaman, also of the geology department, is engaged in field geological studies in the Copper Country in cooperation with the State Geological Survey and the mining companies. Frank Pardee, assistant state geologist, is in charge of this work. This group of scientists cooperating with the Mohawk Mining Company recently completed a survey of the New Michigan exploration where some valuable information was obtained.

Professor George W. Swenson, head of the department of electrical engineering, is carrying on research work in the American Bell Telephone Company laboratories in New York City. His department is cooperating with the telephone company in trying to determine what causes variations in the strength of radio signals, or why radio signals come in strong sometimes and weak at other times. The Copper Country offers unusual opportunities for this study because the rock formations of this district are of such a nature that there are strong local variations in the earth's magnetic field. These same variations are being used successfully in the geographical mapping of the district.

A CORRESPONDENT