results has no connection with the question whether the event is determinate or not.

Darwin may be right when he says that the problem of "free will" "is a philosophic one outside the thought of physics," but such a statement depends on one's definition of physics and of science. It is true if we include in science only those things which are fully known and can be mathematically demonstrated. In an article by Professor Evan Thomas on p. 173 of the same number of SCIENCE several beautiful illustrations are given of important advances in science which began, not with rigid mathematical reasoning or logical conclusions from a set of observations, but by a quite different process. Such advances must always be submitted, afterwards, to the test of agreement with observation, and, if possible, to mathematical treatment. Science would be a very poor affair if it rigidly excluded all ideas for which this process is incomplete—indeed, is it possible to say of any fundamental idea that the process is complete? Science and philosophy, in their higher reaches, should be identical.

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THE UNCERTAINTY PRINCIPLE AND FREE WILL

A RECENT number of SCIENCE[1] contains an extremely interesting article by Professor A. H. Compton, showing the possible effect of Heisenberg's uncertainty principle upon macroscopic phenomena. It illustrates beautifully a point which has been frequently overlooked, namely that, in certain instances, uncertainty is cumulative and creeps into large scale events.

There has been considerable speculation as to the possible significance of this fact relative to the problem of free will. The present note endeavors to clarify the relation between these two issues and to show, incidentally, that no connection between them exists.

We desire mainly to point out two things:

(1) In Compton's example, uncertainty governs the fate of the photon. The response of the amplifying device appears dependent upon the photon's fate. The amplifying action is causal in the direct, acausal in the indirect sense. "Freedom of choice" in the amplifying device would involve its capability of guiding or affecting the photon's fate, a postulational element which is metaphysical and proves to be unreasonable upon closer inspection.

Any attempt to establish the possibility of free will on the basis of physical uncertainty has also a formal flaw from the point of view of the all-embraciveness of quantum theory. The uncertainty principle has transformed the causally closed into a causally open world. Hence a proposal to reverse this transformation would appear inconsistent with recent developments in theoretical physics. It is to be noted that the establishment of free will is such an attempt of filling the causal gap by supplying the lacking determinant in form of the individual's decision, and is therefore contrary, in one sense at least, to the spirit of quantum dynamics. It must be admitted, however, that this last consideration is stringent only for those who refuse to supplement the physical world by extraphysical elements.

(2) The second and major point of this note regards the problem of freedom of will itself. This philosophical problem arose in connection with that of individual moral responsibility and has to do with the determining factors of human motivation. It belongs to a domain which is intrinsically foreign to physical lawfulness and must be distinguished clearly from the somewhat less problematical question of freedom of action. Philosophers have usually observed the demarcation (*actus elicitus voluntatis vs. actus imperatus voluntatis*). Compton's argument demonstrates a possibility for freedom of action—though a very limited one—this action being the release of one of a number of physically indeterminate sequences of events, which occurs after the volition has been formed. But it does not touch the problem of the motivation of this volition. Hence there is no intelligible connection between quantum-mechanical uncertainty and free will.

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[1] "The Uncertainty Principle and Free Will," SCIENCE, 74: 172, August 14, 1931.

THE CLASSIFICATION OF PYTHIUM[1]

SPARROW has presented in SCIENCE 73: 41–42, a point of view on the classification of members of the genera Nematosporangium and Pythium which, although correct in certain respects, is misleading in certain others. He has argued that the genus Nematosporangium be dropped and its members included in Pythium, that certain of the organisms now placed in Pythium be transferred to Sphaerosporangium and that the members of the genus Pythium with lobulate prosporangia be placed in the genus Rheosporangium.

Sparrow is correct in his first assertion in dropping Nematosporangium and placing its organisms in Pythium, as far as priority is concerned. It is true that the original type species of Pythium was *P. monospermum* Pring,[2] which is now included in Nematosporangium. This species, however, is very rare and the genus Pythium became more known and

[1] Published with the approval of the Director as Miscellaneous Paper No. 11 of the Experiment Station of the Association of Hawaiian Pineapple Canners, University of Hawaii.

[2] *Jahr. Wiss. Bot.*, I, p. 288, 1858.

typified by the later discovered *P. proliferum* de Bary[3] and *P. debaryanum* Hess,[4] because of their wider distribution and greater economic importance. Both *P. proliferum* and *P. debaryanum* differ from *P. monospermum* to such an extent as to justify the creation of two genera. Fischer[5] created at a later date the subgenera Nematosporangium and Sphaerosporangium and placed *P. monospermum* in the former subgenus and *P. debaryanum* and *P. proliferum* in the latter. Schröter[6] in 1897 elevated Nematosporangium to generic rank and placed all the organisms then in the subgenus Sphaerosporangium in Pythium. This scheme of classification has been approved by Lindau[7] and recommended by Fitzpatrick[8] and, in the opinion of the writer, it is practical and divorced from complications and ambiguity.

Pythium debaryanum came to be known as the type species of the genus in the pathological literature, because of its constant association with seedling root rot. Very few plant pathologists and even mycologists have ever seen *P. monospermum* but nearly all have had some practical experience with *P. debaryanum*. It is through such an experience that the morphology of practically all pythiaceous organisms has been compared with that of *P. debaryanum*. One will readily see the fallacy and injustice of placing members of the genus Nematosporangium under Pythium especially in the case of *Rheosporangium aphanidermatum* Edson.[9] *R. aphanidermatum* does not vary any more from *Pythium monospermum* than does *P. proliferum* from *P. debaryanum*. It is, therefore, as true a member of the genus Pythium as the type species *P. monospermum*. Yet, in spite of all this evidence, Edson created the new genus Rheosporangium to find a place for his organism! The writer believes that the fault is not with the investigator, but with the taxonomic system because it has failed to differentiate properly between completely distinct organisms.

Sparrow recommends the reestablishment of the genus Rheosporangium to include all those members of Pythium with lobulate prosporangia. It is very unfortunate that Sparrow did not read very carefully the description of *P. monospermum*, or else he would have noticed that the hyphae of this organism possess bud-like outgrowths which came to be known by later investigators as prosporangia. The German text in connection with the lobulate prosporangia of *P. monospermum* reads as follows: ". . . Fäden oft mit vielen Kurzen annähernd rechtwinkelig ansetzenden Seitenästen. . . ."

My answer to Sparrow's criticism of my paper[10] for the non-segregation of members of Nematosporangium with filamentous prosporangia from those with lobulate ones is that I have never seen any species of Nematosporangium (*Pythium monospermum* type of organisms) lacking the lobulate prosporangia (bud-like outgrowths of Butler or plasmatoögoses of the writer.[11] These bodies vary in size and number in different species, but they are present, nevertheless, in all species. With species which reproduce sexually very readily and abundantly the lobulate prosporangia are not very numerous, and *vice versa*.

If the recommendations as proposed by Sparrow are accepted there is a danger of leaving the genus Pythium without any members. If all of the species with lobulate prosporangia including *P. monospermum* are placed in Rheosporangium and those with spherical prosporangia including *P. debaryanum* in Sphaerosporangium, then there will not be left any more members for Pythium.

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[3] *Jahr. Wiss. Bot.*, II, p. 182, 1860.
[4] *Dissert.* Halle, 1874.
[5] Rabenhorst's "Kryptogamen Flora von Deutschland, Oesterreich und der Schweiz." IV. *Abt. Leipzig.* 1892.
[6] *Engler-Pranlt.* "Natürliche pflanzenfamilien. Pythiaceae, 104–105, 1897.
[7] "Die mikroskopischen pilze," Berlin, 1922.
[8] *Mycologia*, 15: 166–173, 1923.
[9] *Jour. Agr. Res.*, IV: 279–291, 1915.
[10] SCIENCE, 71: 323–324, 1930.
[11] *Mycologia*, 23: No. 4, 1931.

"TASTE DEFICIENCY" FOR CREATINE

THE observation that to certain individuals *p*-ethoxy phenyl thiourea tastes bitter, while to others it is tasteless has led to Professor L. H. Snyder's study of the inheritance of this taste deficiency as reported in SCIENCE for August 7, 1931.

A few years ago the writer, with Mr. P. A. Lasselle,[1] noted a somewhat similar situation with regard to the familiar muscle constituent creatine. We had a sample of what eventually was proved to be this substance submitted to us for identification. The melting point recorded in the literature was somewhat in error, but the properties of the substance suggested that it might be creatine.

Creatine, however, was described in the literature as bitter, whereas the substance in question seemed to both of us to be as tasteless as chalk. Further study convinced us, nevertheless, that it was actually creatine. It was not, I believe, until we had submitted it to the fifth person that we found one who reported a bitter taste.

The fact that even this familiar food constituent has these distinctive reactions on different individuals is perhaps a significant one. Since a pound of lean meat may contain nearly two grams of creatine it

[1] *Jour. Am. Chem. Soc.*, 48, 536, 1926.