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.