contain weighing, drying and preparation rooms and facilities for cleaning and storing seed stocks of various kinds. For the fruit farm near Zumbra Heights in the Lake Minnetonka district, $9,000 was appropriated for the purchase of additional land and $13,500 for an office building and laboratory. Nearly all the investigations in fruit crop breeding are conducted at this farm, and the laboratory will provide much-needed facilities and greatly expedite the making of records and the interpretation of results.

DISCUSSION

CYCLONE AND ANTI-CYCLONE

IN some recent letters, published[1] and personal, Sir Napier Shaw suggests that we might with profit employ the terms *"air-sink"* and *"air dump"* for cyclone and anticyclone. Both of the last-named have done honorable service, and it will be long before they are eradicated from conventional usage in all treatises on airgraphics. But even as we are eliminating the almost unpronounceable word meteorology, so we may gradually dispense with terms that have outlived their usefulness. Cyclone came to us from Piddington, with the Greek κυκλος or coil of a snake, and anti-cyclone from Francis Galton, as the opposite of an uprising, rotary wind structure. It would now seem that we have unconsciously overstressed the importance of the circulatory air flow in a depression or cyclone; and so neglected the scooping-out or removal of air on the one hand and the heaping-up or cumulative effect on the other, which is so aptly pictured as a *dump*. This overstressing of the "low" as shown by the surface air flow and a positive insistence upon the fundamental physical relation that air flow is initiated by pressure, and pressure only, has resulted in missing a most important factor in the formation of areas of high and low pressure.

To quote Sir Napier Shaw:

> So pressure-gradient comes to be the mere index of the response of an air current to the centrifugal force of the earth's rotation aided or counteracted by any local curvature of the air's path.

Here then we come to a new point of view, as explaining the origin, also maintenance, of highs and lows, and this is of importance in forecasting the weather, and an understanding of the daily maps. Cyclone and anticyclone are really created and maintained by the winds of the straight isobars that lie between them. To quote further from Sir Napier

> The high and the low are mere incidents of the relative motion of the air currents of different directions. In the northern hemisphere wherever the passing currents keep the English rule of the road, with opposing traffic on the right, high pressure (and generally fine weather) between them is the inevitable consequence; but wherever the atmosphere adopts the continental rule of keeping the opposing traffic on the left, there a "low" between them is equally inevitable.

This fundamental law in forecasting we have recognized for some years at Blue Hill Observatory, and may be expressed briefly as, "An air flow from northwest, north or northeast, in advance of a flow of warm, moist air from south or southwest, is less likely to give precipitation and form a depression than when the southerly air flow is in advance of a dry, cold flow from the north." In keeping with the new point of view, we should perhaps mark storm paths, not from the loci of minimum pressure but from the points of wind conflict.

Much more could be said concerning an automatic balance between wind velocity and gradient under the influence of the earth's rotation; but it must suffice for the present to call attention to this shifting of attention from pressure minima to air-flow effects as the really important dynamical agents.

Sir Napier has also calculated the energy of the horizontal motion of a 100 meter layer of air, in thickness, with pressure interval of 2 kilobars as approximately 26,000 kilowatt-hours, varying with height and latitude.

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[1] *Nature*, June 27, 1931, "Potential Temperature and the Stratosphere"; August 8, 1931, "The Energy of Horizontal Atmospheric Motion."

THE UNCERTAINTY PRINCIPLE

IN his note on "The Uncertainty Principle and Free Will" published in SCIENCE for August 14 (p. 172), Professor A. H. Compton seems to overlook the important distinction between a thing which is *indeterminable* and one which is *indeterminate*. No one can predict with accuracy and certainty what the weather will be to-morrow, to say nothing of predicting what it will be a week or a month hence. But I think no scientific man would claim that because the weather is indeterminable it is indeterminate—that the weather to-morrow will not depend, inevitably, on conditions which exist to-day.

It may be an "even chance" whether the photon of which Professor Compton writes will enter one or the other of two photoelectric cells, but it is illogical to suppose, for that reason, that the conduct of the photon is not determined by complex conditions of such a character that prediction is impossible. The fact that so minute an event may produce tremendous

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.