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DETERMINISM AND RESPONSIBILITY[1]

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THERE is an old saying concerning the Christian ministry. "Every man must be an Arminian when he preaches, and a Calvinist when he prays." That is, in the first case he must emphasize free-will; and in the second, divine providence. This is far more than an epigram; it is an effective statement of an intellectual difficulty which besets religion, philosophy and science alike. Even the most case-hardened mechanist of the old nineteenth-century school had no qualms about asking his neighbor at table to pass the butter.

It is bold to attempt even a partial resolution of this ancient antinomy; but I am convinced that it may be very considerably clarified with the aid of concepts derived from physical science. In a round-table discussion, voices of protest would rise here. "Have you forgotten Heisenberg?" "Has not modern physics abandoned determinism, and committed itself to a principle of indeterminacy?"

Some ground must be cleared here before the discussion can proceed. It is not only in past centuries that mischief has been done by the unfortunate choice of a name. If the great physicist who discovered the "uncertainty principle" had only called it the "Principle of limited measurability" (as Max Born did a few years later) we might have been spared a great part of the "awful outbreak of intellectual licentiousness" which Bridgman all too truly foresaw among the half-informed.

The principle is of the type which Whittaker has recently called Postulates of Impotence.[2] Like New-

[1] A paper presented at the Third Conference on Science, Philosophy and Religion, New York, August 28, 1942.

ton's postulate, which amounted to denying the possibility of finding any unique state of absolute rest in nature, or Einstein's, which makes a similar denial regarding absolute motion, it has clarified so many difficult problems that it has won unanimous acceptance among physicists. Simply put, it denies the possibility of measuring the position and motion of any particle simultaneously and with perfect accuracy. The better we do with one, the less we must be contented with for the other.

The difficulty arises from the fact that the means of measurement themselves can not be refined to absolute perfection, because nature is not fine-grained enough. Matter, electricity and radiant energy all come in discrete packets—atoms, electrons, quanta—and no experiment can be made upon a single one of them except by hitting it with another, and thereby seriously disturbing the situation which we desired to study and measure.

There are many things which we physicists would dearly love to find out that nature won't let us—for example, what was the difference between the atom of radium which blew up last second and its neighbor, which will go on for centuries before undergoing the inevitable, but long-delayed, change.

We have no present hope of finding out why one atom disintegrates and not the other; but I, for one, am convinced that this does not justify us in saying that there is no reason. We must be agnostic about the question, but may not proclaim a negative dogma. The most that we can do is to say that, since no experiment made with the aid of anything known to exist in nature gives any hope of answering the question, it is "not physics."

One conclusion is clear. The nineteenth-century image of a vast, though finite, intelligence, which could determine at a given instant the exact positions and velocities of every particle in a (finite) universe, and their laws of interaction, and thus be enabled to predict with absolute accuracy the whole future history of the universe, is also "not physics." Such a perfectly detailed prediction of phenomena, even on the atomic level, is out of the picture.

Must we then be indeterminists? The only one I ever heard of was described to me by Dr. Watson, of the American University at Cairo. Visiting a date-grove, he asked his Mohammedan host, "What is the average life of a palm-tree?" and was answered "That will be known only after the Great Day of Judgment." His request for elucidation surprised the Moslem. "Surely you Christians believe, as we do, that all things are determined by Allah's Will." "Truly." "Then, when He says to a date-stone 'Spring up' a palm grows. When He says to that tree 'Die' it dies. Only when the Great Day is over, and the affairs of earth are ended, will it be possible to know what average age Allah, in His wisdom, has assigned to a palm-tree." Here is the true Indeterminist—an educated man, believing in an almighty, just and compassionate, though somewhat arbitrary, God—but not in the law of averages.

Hardly any philosophy could be more at variance with modern physics. There is very strong evidence that—though the individual quantum-jump is unpredictable, the distribution of the results of large numbers of them is strictly governed by the laws of probability. The average results for successive groups of the same number of cases, though not identical, differ from one another, and from a general mean value, by small percentages, which grow steadily smaller as the number of cases in a group is increased. In the rare instances where single quantized events produce directly observable results, fluctuations in space and time are conspicuous—as may be seen by looking at the dial of a "radium watch" in the dark with a hand-lens. But, even here the apparent disorder of the unequal intervals has an underlying statistical order. Not only is the average value of the successive intervals substantially the same, for large groups, but the percentages of individual intervals which are (say) less than half, or more than twice the general mean, tend, for increasingly large samples, to definite values, predictable on well-known mathematical principles.

Most directly observable phenomena depend upon a number of atomic events which runs far beyond the possibility of counting in mere billions and trillions. In consequence, the statistical fluctuations in the averages of successive similar trials shrink below the limits of the best measurements and individual uncertainty is transformed into practical certainty. Strictly speaking, this is only a high probability; but the probability can be calculated and is so terrifically high that it is more impressive than any dogmatic assertion of certainty.

Take a very simple case—a glass globe containing 100 small smooth balls, just alike except that 50 of them are white and 50 yellow. If the globe is thoroughly shaken and set down, the balls will settle into a circular patch at the bottom. It might happen, by pure chance, that all the white balls fell into the north half of this patch, and all the yellow ones into the south half; but the probability of this is 2^{-50}, approximately one chance in 1,126,000,000,000,000. The thing might happen; but it would be throwing away money to bet one cent against the whole cost of the war that it would.

Before I can develop my main argument, I must ask you to go a bit farther with me into this strange territory, and consider the meaning of what are called "statistical properties."

[2] E. T. Whittaker, *Proc. Roy. Soc. Edinburgh*, 61: 168, 1942.

A classic illustration is the pressure of a gas. For several decades, in the actual growth of the science—and, for a few weeks, in an introductory course in physics to-day—a gas was, and is, regarded as an elastic fluid, filling uniformly the whole space between the walls by which it is confined, and exerting upon these walls a pressure (a force per unit of area) which is continuous—the same on all equal areas, however small, and at all times (so long, of course, as the general conditions are not changed).

Before the student's first year in physics is over he learns more. The gas is no longer regarded as a continuous medium, but as an assemblage of a vast number of molecules, flying about in every direction and rebounding from one another and from the walls. The impacts on the walls produce the pressure. Over sufficiently small areas of wall, and small intervals of time, they are not even roughly uniform; but for areas large enough, and times long enough to use in making ordinary measurements, they are so numerous that they average out to practically the same result every time.

Now the mathematical picture of the uniform continuous pressure is a very great deal simpler to work with than the innumerable individual impacts. Under ordinary engineering conditions the averaging-out process is statistically good to one part in a million or better. Consequently, the engineer adopts the simple generalized image of pressure with entire security that the calculations, based on it, will be as accurate as he ever needs them to be. From his standpoint, gas-pressure is an obvious reality.

But the physicist, or the technician, who works with a "high" vacuum, is in a very different position. He can make the number of molecules in his apparatus so small that the averaging-out process becomes trustworthy to only one part in a thousand, then one in a hundred, one in ten—and finally not at all. He has to think about the individual molecules and atoms if he is to make any sense of his observations—and when he does he gets results of practical value such as the tubes used in every radio set.

It can now be understood why a statistical property has some remarkable characteristics. (1) It is a creation of the human imagination designed to describe the relations of observed phenomena. (2) It is a simplified description of an excessively complex underlying situation. (3) It is of great theoretical and practical utility, both in science and technology. (4) Over a wide range of conditions it enables us to predict the results of experiment more accurately than we can hope to measure them. (5) Beyond the limits of this range, it gradually disagrees more and more with the facts.

Practically all the physical properties which we ordinarily attribute to material bodies, such as density, temperature, elasticity or surface tension, are statistical in nature. It is these properties which are connected by the familiar empirical "laws of nature" such as the laws of perfect gases, or those which govern the similar, but more complicated, behavior of steam. These laws express statistical relations, and predictions from them possess, not certainty, but a statistical probability which under ordinary circumstances comes to the same thing.

With these foundations laid, we may approach the problem of human conduct and responsibility.

Man is in part, at least, a physico-chemical system of extreme complexity. No attempt will be made here to discuss the question whether he is also, and essentially, something more and "higher"; but it will be profitable to explore some of the consequences of the hypothesis that man is entirely a physico-chemical system. This means that, given sufficient knowledge of the system and sufficient technical skill in analysis, it would be possible, by the methods of science, to deduce from the structure of the system the properties of human beings—whether physiological, psychological or social—unless, indeed, the investigation was blocked by the appearance of another postulate of impotence.

I am not asking you now to accept this hypothesis, but to consider its consequences, assuming that no impotence intervenes. Two conclusions may safely be drawn.

(1) The properties of mankind, predicted by such a theory, must coincide with the actual properties as revealed by empirical observation. New relationships among these might be opened up and old descriptive formulae superseded; but, if the theory predicted properties different from those which men actually have, it would be a bad theory, and the possibility of the physico-chemical explanation would be "not proven."

(2) The properties predicted by a successful analysis would be of the nature of statistical properties.

Among the most obvious and important properties of man is self-determination. Whether we consider the behavior of others or our own conscious experience, a great number of varied observational data may be reduced to order and empirically "explained" on the hypothesis that the normal human individual is a conscious person, possessing (within limits) intelligence and memory, and with a very considerable degree of control over his words and actions. We all act on these postulates every day—almost every hour—and it would be practically impossible to live through a day of normal human relations without acting on them. My old friend, Professor E. G. Conklin, tells of a conversation he once had with Jacques Loeb. "After he had vigorously denied the reality or possibility of human freedom, he saw his little son running down the steps with a large open

clasp-knife in his hand. At once he shouted, 'Bobby, close that knife. You might fall on it.' I said 'Now, Loeb, practice your philosophy' and in reply he merely winked one eye at me."[3]

It is an immediate consequence of these postulates that the normal individual may reasonably be held responsible for his voluntary actions. Without this principle, organized society could hardly exist.

This naive statement of the situation suffices to introduce the main point of my argument. If an interpretation of the human individual as a purely statistical system is assumed to be possible, then the empirical characteristics of consciousness, memory, reason, self-determination and responsibility must *ex hypothesi* appear as statistical properties of this system—or at least be capable of precise correlation with such statistical properties. Otherwise, the thing which the system represented would not be human.

If freedom and responsibility were statistical properties, we might expect them to have the distinctive earmarks of such properties. They are undoubtedly concepts of empirical origin and of very great theoretical and practical utility. Whether they are simplified descriptions of a complex underlying situation is not at present determinable beyond debate—we know too little of the nature of man.

But it is generally recognized that freedom and responsibility have their limitations. Some of these are purely intellectual—we are not free to imagine a polyhedron with plane faces and seven edges—and here the limitation is absolute, for we can prove that no such configuration exists.

But the responsibility to which a man might reasonably, or, if you will, justly, be held by a precise analysis, varies with the knowledge, intellectual capacity and often with the physical strength of the individual and, for the same individual, must take into account changes in health, fatigue, anxiety and a hundred other things. I owe again to Conklin the suggestion that responsibility fully assessed to the limit of its ethical significance is a continuously varying quantity. All men are equally responsible before the law—yes, because the portion of a man's whole range of moral responsibility to which the law fairly may—or actually can—hold him is so small a fraction of the whole that individuals who fall below this level may be regarded as defective. The law itself recognizes this exception.

At the limits of the field of responsibility we do not find a sharp boundary separating complete and absolute responsibility from its utter absence. There is, rather, a gradual falling off with changing circumstances—as is tragically illustrated by the progress of degenerative physical or mental disease.

More might be said if time permitted; but it is already evident that responsibility possesses the distinctive ear-marks of a statistical property, whether it is one or not—and the evidence in the case of freedom is similar.

I may now at last make bold to announce my principal thesis: The mechanistic hypothesis of the nature of man (in the statistical sense described above) is not an enemy, but an ally, of morals and religion.

I do not contend that this hypothesis is scientifically established—though the evidence in its favor appears to me to be strong;—and I leave its general philosophical implications to those versed in this discipline. But it goes a long way toward resolving the ancient dilemma of fate or freedom.

This takes its sharpest form when expressed in theological symbols—predestination versus free-will. In this presentation, indeed, it appears hopeless—an antithesis between human wills and a divine will, conceived as similar in nature, though with infinite wisdom and power behind it.

But, on the mechanistic hypothesis, the determinism enters through the structure of the underlying system, while freedom and responsibility are statistical properties of the assemblage, man. The antagonism is no longer acute, for one of the most distinctive features of the statistical properties of a system as a whole is that they can not be found in the characteristics of the individual particles which compose it. On the lower level of interpretation the statistical properties are not present. But on the higher level of integration they are the important ones, and suffice, in theory and practice, for the discussion and study of the system. Pressure, temperature, elasticity, and the like, are realities for the engineer. The physicist may use either terminology, according to the nature of his particular investigation; but he must be careful not to mix up concepts belonging to two different levels. It would be fatal, for example, to think of electrons shot out into a gas as if they were moving through a continuous medium; and to speak of the pressure or temperature of a single molecule in a gas is meaningless.

When considering the social, ethical, esthetic and religious relations of men, we start automatically on the higher level, and consciousness, reason, personality, freedom and responsibility are the concepts relevant to studies on this level. These studies are difficult enough, Heaven knows; but this is no reason why we should bedevil ourselves by introducing at one point, and at this point only, deterministic concepts belonging to a different level of interpretation.

The trouble comes from introducing determinism and rejecting freedom and responsibility while retaining other concepts belonging to the higher level, such as consciousness and personality. It is imaginable

[3] *The Rice Institute Pamphlet*, 28: 218, 1941.

that to some vast Intellect, which saw through the desperate complexity of our nature, responsibility and freedom would be replaced by deterministic concepts, intricate beyond our very imagining. But there is every reason to suppose that personality and consciousness would also be replaced by similar unimaginables. To such an Intellect men might not appear to be persons either. Least of all would they be conscious automata.

The answer to the question, Which is the reality and which the illusion?—or, better, Which seems to be the illusion, and which the reality?—depends on the direction from which the problem is approached. To our hypothetical Intellect, the underlying complex would be the more real; but we, who approach things from the surface, see reality in the concepts that lie nearest us. These have value and importance to us, not because they are ultimate—if there be any ultimates—but because they are proximate. We needs must act as if they were real, and we are justified in doing so. Do you remember Kim and the Red Lama in the Himalayas? "Look and know illusion, *chelä!* These are the true Hills!"

It is, of course, still hypothetical that such an interpretation of humanity is possible at all. But we know that there is a maze of subordinate levels—atomic, molecular, colloidal, cellular, physiological, psychical, and perhaps more—through which the way would be exceedingly difficult to follow, even if it were communicated to us.

Why, then, should we vex ourselves with such fine-drawn speculations? There are two strong reasons. First, the evidence in favor of statistical determinism in physical phenomena is overwhelming; and there is a great weight of physiological and psychological data which support the belief that we ourselves are not exempt.

The effects of certain drugs, and of some diseases, upon the higher aspects of personality provide the most appalling evidence. In a lighter vein, but provocative of earnest thought, is an old quip, from the days of Lister's medical teaching at Edinburgh: "No one ever died a triumphant death of trouble below the diaphragm."

These are but glimpses of a mass of evidence which puts the mechanistic hypothesis very seriously in court.

But the insistent problem, in times like these, is religious. There is no scientific difficulty in the belief that God, if He exists, controls the universe completely. Postulates of impotence need not be made concerning the Deity. It is hard to believe that a morally perfect God controls the world in which we struggle. But if we deny this—if God is not all-powerful—if the evil wills of "the rulers of the darkness of this world" are outside His control, then the victims of oppression are indeed of all men most miserable, and there is no ultimate security anywhere. If we have any religion at all, we will pray in these days—and it is to God Almighty that we must pray.

This faith—that God knows why He made the world this way, though we do not—has supported those who "subdued kingdoms, wrought righteousness . . . turned to flight the armies of the aliens." We need it desperately to-day, and we need equally faith in freedom.

May we not have both, and be spared one more chapter of the weary history of the warfare of science and theology, if we accept, tentatively at least, a mechanistic but statistical hypothesis of our own nature? I have tried to show that this involves no abandonment of belief in responsibility or freedom, and in another place[4] and at length, I have argued that it is fully consistent with belief in personal immortality. So far as I can see, the validity of intellectual and moral values is not impaired.

We have indeed to make one sacrifice; we will no longer be inclined to think of ourselves as irreducible spiritual units possessing some sort of ultimate reality independent of all else but God. But this hurts only our pride—and is likely to be good for us.

THE NEW YORK ZOOLOGICAL SOCIETY[1]

By Dr. HENRY FAIRFIELD OSBORN

Members and Friends of the Zoological Society:

YOU come here each year for better reasons than hearing a long formal, detailed summary of the past year's activities. This will find its proper place in the printed Annual Report to be submitted to you at a later date.

The past year, however, has been an extraordinary year—a year of war. I feel therefore that comments should be made to you as to the situation of the Society in wartimes; that I should touch upon two or three of the major highlights of the year just ended—also speak briefly of the future.

The outstanding fact is that the activities for which this institution is responsible appear to mean as much to the public in days of war as they do in days of peace. Consequently, we have undertaken to maintain all our normal activities throughout the past year not

[1] Address at the Annual Members' Meeting of the New York Zoological Society, on January 12, 1943.

[4] "Fate and Freedom," Yale University Press.