point them all in the same direction, say toward the center of the volume. When and if this ever happens, water would tend to freeze on fire instead of boiling.

In a similar way, the molecules in a desk are in random motion, and if random, might permit the desk some day to rise from the floor when all its molecules happen to be vectored upward. In the case of both the water and the desk, the odds are almost infinitely against the variation of their normal behaviors. But so long as their basic movements are random in character, the freezing of the water or the ascension of the desk must be deemed at least mathematically possible.

The treatment of thermodynamics by statistical techniques thus leads to results at variance with the law of entropy. This law, for many an empiriological physicist, no longer states the direction of energy flow with the rigor of classical thermodynamics. The law is most frequently viewed now, at least in theory, as stating only probable direction.

In a sense, a very important one, statistical mechanics eliminates the notion of heat from thermodynamics and tends to eliminate thermodynamics itself. There is no heat in a single atom. Heat results from the random movement in an aggregate and it is not a property of single particles.

But there is another way in which statistical mechanics recovers the idea of heat if not the formal laws of thermodynamics. Heat is defined as a disordered motion of particles, and disorder is the law of the atomic underworld, statistically explored.

The law of entropy states that all exchanges of energy involve a certain loss of heat which is no longer usable to do work. The quantity of heat thus increases with every cosmic process. But heat is a disorder, and where the Aristotelian universe was angled to order, the modern universe is said to be rampaging toward the opposite. Entropy or disorder, the empiriological physicist says, is always on the increase. The universe, he goes on, is becoming more random and hence moving from a less probable state to a more probable one.

RANDOMNESS IS NOT A CHANCE

It is possible now to evaluate the notions of chance which have been sketched. In tempering the extreme views which the devotees of scientism adopt, recourse might be had to the proofs earlier set down that finality is operative in nature but that mere measurement cannot come to a full and formal appreciation of its reality and force. It could also be shown that the empiriological physicist, as such, cannot possibly speak of order and disorder, chance and antichance, because such factors are recognized not by yardsticks and chronometers in the realm of quantity but by insight into motion. This would all be sufficient to turn back the indeterminism by which the empiriological physicist challenges the philosophical science of nature.

But the approach of philosophical physics can be toughened by pitting some of the modern views on chance against it, using reality to arbitrate the dispute and to show the strong points in the contemporary views and also the weaknesses.

It is important to note at the very beginning that chance is an equivocal word and that philosophical and empiriological physics are talking about two quite different things. Chance, in its physical and real implications, can be defined only in terms of final causality. It involves motion and in this setting was seen to be an aberration from a motion's natural destiny. Chance on the modern scene is not primarily of motion but of quantity, and removed from the world of tendency and teleology it is not properly chance at all.

This might be made clear by distinguishing chance from randomness. A random distribution of units forming a collection means that the whole is homogeneous and is a form of order where the parts are scattered equally throughout the aggregate. Such an aggregate is mathematically treated. The order which it reflects is defined by reference to a mathematical system, and mathematics, unconcerned with final causes, does not deal with chance.

True chance, on the other hand, is something physical. If the random collection is set in motion, then it is subject to the element of chance. Its random character, its homogeneity, might be disturbed by an extrinsic causal series, and the disturbance of the random order would be a chance event. A dice game can be studied mathematically. The statistician can predict how many sixes will occur in, say, 2000 random throws. But he supposes the random order which chance, the disorder factor, might disturb. What is random follows law, as the concept of an average can show; what is chance is lawless, unpredictable. What is random has a type of order; what is chance is disordered.

STATISTICS IMPLIES DETERMINISM

It is obvious that a statistical whole composed of elements that are apparently disordered is in reality an ordered whole, like the ratio of heads to tails over a great many throws of the coin. But such a whole is nothing but the sum of its parts, and if the whole is ordered, the parts must likewise be ordered in ways perhaps that man is unable to follow and record. If the units forming a collection were utter chaos, following the laws or rather the lawlessness of chance, no order like averages, radioactive half life, and thermal equilibrium would occur in the whole. Scientism, mistaking its own ignorance for nature's blunders, prides itself on apparent proofs that nature is disordered, but the existence of evident law in an aggregate argues that the parts comprising the whole are law-abiding too.

Order does not depend for its existence on our ability to measure it. To acknowledge as order only what man can measure with quantity and vary with instruments is anthropomorphic in the extreme. In fact, order as such has nothing to do with quantity; it is woven from the tendencies of natures to their ends and cannot be detected where reality is approached as something indeterminate and inert. If the small particles, believed in empiriological physics to be governed by chance, had no tendencies of their own and hence no order to ends, they would be wholly

indeterminate, not only unable to act but unable even to exist. The occurrence of order in the statistical whole is a confirmatory argument for the order that the particles must obey individually to operate at all and even to exist in the world of mobile things.

This general rejection of a universe as governed only by chance applies alike to the classical and the quantum applications of statistics.

In regard to quantum methods, the wave equations of Schroedinger start with the probability of positions and energies and predict the ordered variation of that probability as time goes on and the positions and energies change. The probability in the premises is connected with the probability in the conclusions by order and by law. The difficulty in quantum physics is not the connections of the present with the future, which is order, but the inability to get exact knowledge of the present as leverage for prediction.

THE HEISENBERG PRINCIPLE IMPLIES ORDER

The Heisenberg principle sharpens this conclusion. In scientism, the principle tends to transfer a difficulty in measurement to a disorder in nature, leading to the verdict that nature is indeterminate. To drum home the truth that the uncertainty relation represents a subjective or logical indetermination, meaning of course an inaccuracy in measurement, and to show that it does not mean a disorder in nature, the philosophical physicist may propose the following argument:

A standard must be chosen with respect to which the indeterminism is said to exist. If it is said that a thing is disordered, there must be an order as a standard for deciding that there is disorder. Now this standard must be either subjective or objective. If the standard is subjective, so is the indeterminism which it defines, and this is what the philosophical science of nature would hold, a subjective and logical indeterminism as the issue of the Heisenberg principle. On the other hand, if the standard is objective, then all is not indeterminate in the world. At least this standard of order, with respect to which disorder is defined, is determinate and law-abiding.

Bergson and Bradley could be applied here in their agreement that "chance" is not disorder but order of a different type from the one expected. This "relative chance," as both Bergson and Bradley term it, is what the empiriological physicist, in classical or quantum garb, really means by disorders, and "chance" is thus objectively an order of a different type from the one that is of interest in a problem. The definition of "chance" in quantum physics rests on a prior definition of order and is real or not, depending on whether the norm of order is real or not.

TRUE CHANCE IS REAL

Chance, as Francis Bacon said, reflects man's ignorance more than nature's aberrations. And that ignorance, removable completely only by a knowledge of all possible fact and its combinations, which can also be called facts, cannot be overcome. With Chapter 4 for a background, it can now be stated that fact is as infinite as prime matter, i.e., potentially or privatively infinite. This can be shown, to take a telling example, by the divisibility of matter *ad infinitum,* and the tendencies of empiriological physics to pursue this infinite road by dividing matter, subdividing the divisions and then the subdivisions, without end. Each pace along the road of dividing matter yields a new fact that is somehow capable of altering the mobile world and of being experienced by man. But though man, in principle, can know the basic character of a nature at a single glance, he can never know all possible fact except through the impossible task of traversing the infinite series. Hence, the growth of knowledge cannot overcome true chance, a disorder arising from the crisscross of causal series.

Man's knowledge is of universals. He can never know all there is to know about individuals. God has such knowledge, and for Him nothing happens by chance. To this extent, Bacon is right. But man lives in a mobile world where individuals are in motion, and though knowing the general features of the individuals that move and knowing even their species, man can have a certain knowledge only of law; his knowledge does not exhaust all possible fact—let alone its combinations—which can be multiplied as much as individuals can be divided, hence multiplied indefinitely.

Ignorance in matters of physical chance, which is what Aristotle described, may be called negative ignorance, as opposed to the privative type. If a book cannot speak, it might be called dumb in a negative sense since speech is not owed to the nature of a book. But for a man to lack speech is privative dumbness, the lack of a perfection that man ought to have. It is in the sense of this contrast that ignorance in cases of true physical chance may be called negative.

But ignorance of molecular movement, for example, because it is difficult to measure individual particles, is a privative ignorance. It is possible to remove it but extremely hard to do so. Removing it is theoretically but not practically possible. Since the smallest atom is at least 1800 times as large as an electron which would be used in an electron microscope to "see" it, a single electron would not appreciably disturb a hydrogen atom or molecule, and it is theoretically possible to chart the course of any molecule presently said to move in random fashion because exact measurement of its path is so difficult. But it is not theoretically possible to overcome our negative ignorance in cases of true chance. Empiriological physics, by its concept of randomness, stresses a new and negative type of ignorance overlaid upon the natural and privative type which true chance involves. Randomness is methodological chance, but true chance is real.

EMPIRIOLOGY RIGHTLY TENDS TOWARD THE CHANCELIKE

Empiriological physicists are usually concerned with theories as tools to predict their experiments, and they should not, the good ones insist on this, impute an ontal value to theoretical constructions. Do not try to picture reality, they enjoin their students; accept as fact only the laboratory data which theories predict.

If scientism followed this counsel more carefully, it ought to conclude that the supposition of random partition which lies at the bedrock of its statistical superstructures does not imply that reality is really a jungle.

There is, however, a realistic backdrop for the empiriological belief in the randomness of microscopic events, which increases the more matter is divided. Simon has sketched the idea that the more an atom is divided the more parts there are and the more likelihood there is of interferences among causal series.[2] Besides, the more plural the world becomes, the more inert it is, and the more inert or extrinsic to itself, the more chancelike, according to the reasoning which Bradley suggested earlier in this chapter.

Moreover, the success of empiriological physics in exploiting the universe by taking its atomic rhythms as random tends anew to confirm rather than deny an Aristotelian version of what empiriological method is about. A random distribution is continuous and homogeneous and indeterminate, and the mineral world which is so little under the dominion of form and hence so much under the sway of matter tends to approximate this the more matter is broken up.

It was a thesis in Chapter 6 that the more matter is sundered, into subatomic particles for example, the more the inertial factor increases and the less form the units have. Empiriological physics, it was said, tends more and more to prime matter. But if atoms, and subatomic particles even more so, are almost random, almost inert, almost indeterminate, the *almost* is too important to neglect since the structures and substructures of atoms still have a minimal form necessary to keep them in existence as mobile beings when in a free state. The philosophical physicist can explain the success of the empiriological itinerary when it assumes that microscopic particles and their movements are random and indeterminate. That is almost what such realities and such events truly are. Their form is poor and their final cause is weak. That is why they are so controllable.

[2] *Prévoir et savoir,* pp. 60–61.

They are logically general.

THE ALLEGED EXAMPLES OF DISORDER INVOLVE ORDER

But there is still enough form and finality left, wherever an entity like an electron or a meson exists even momentarily in isolation, to make for the order that obtains between tendency and end; otherwise, there would be the indeterminacy and chaos of prime matter. This minimum of form, attracted by its end, insures that the boiling of a kettle on fire which normally takes place will continue to occur when external conditions are the same. It could guarantee the stenographer that her desk will not suddenly leap up at her when she is writing a letter.

Perfect randomness can exist only in mathematics with its equalities but not in nature with its hierarchies, nature where there is something more than quantity and its distribution, namely, motion and its laws. Each molecule of water in the kettle and each cellulose molecule in the desk is endowed with definite tendencies, and the sorting of the tendencies into the one that a motion actualizes in preference to the others is the work of the end. The motors, responsible for the motions of things, are likewise governed by final causes. The tendencies are weak it is true, and the ends are feeble, as evidenced by the control man clamps upon the mineral world. But there are still tendencies and still ends. Changing them means changing the thing that they affect.

An electron in the example of the vacuum tube will not turn backward to the cathode unless something changes it, and it will then respond by seeking the end which is natural to it under the changed circumstances. An electron is not self-moved or chancelike. When a cloud of electrons collects around the anode to which they were originally directed, it has the effect of generating a negative plate because the electrons are negative in charge. This negative cloud thus acts to repel electrons and to drive them backward toward the cathode from which they came.

Is it possible for all the molecules in a gas to line up some day in a direction toward one side only of a cubical container, exerting zero pressure on the other five walls? No, not unless an external motor coerces them from their three-directional movement into a one-directional path. If a zig is changed to a zag, there must be a cause for the change, and there must likewise be a final cause to explain why the particle took this direction rather than another.

Whatever is moved is moved by an external mover. Whatever changes motion is changed from the outside. Obeying final causes, the molecules are not spontaneous and self-moved entities, capable of picking and choosing the tendencies that they will favor in response to a causal impact. If they are in random motion, random in the mathematical sense of being homogeneous in partition and tridirectional in their paths, they will always so remain until they are changed from the outside and follow their final causes in the new set of circumstances. Once in zigzag motion, they will continue in it, unless external conditions change.

Will the desk take off from the floor and hit the stenographer in the face as it moves upward? It will do this only if an external agent moves it thus, changing the present tridirectional motions of the molecules into a direction entirely upward; and the molecules, obeying their final causes, will respond to the mover. In other words, where conditions in matter are the same the results will be alike also.

NATURE HAS A COUNTERPART TO RANDOMNESS

Where final causality is outlawed and matter is viewed as self-directed, anything can happen, and the empiriological physicist, who ignores causes and prefers descriptions, is justified in his conclusions about the disorder in things and their basic unpredictability. If Descartes is right, so are the indeterminists. If

Hume prevails and things arise spontaneously without a causal dependence on something preceding, then any motion or change in motion can occur at any time or any place. It is causality that makes for order, and causal knowledge that makes for certitude.

But if there is sufficient form in even the frailest mobile entity to save it from the chaos which a purely passive universe would become, and if there is a sufficient end to assure that any movement must be somehow ordered and directed to a goal, empiriological physics must forge its passport to make its way into a philosophical science of nature with such doctrines as the indeterminists propose.

The empiriological physicist, if he only recognized his aim to control nature rather than to contemplate it, is so close to being right that he mistakes his proximity to a truth as the final and whole science about the material world. There is something in nature corresponding to his enthusiasm. It is primordial matter, indeterminate, purely passive, inert, chaotic, indifferent, and chancelike. And the more the empiriological physicist descends through the lower stories of matter the closer he gets to this primordial substrate which the philosophical physicist joins in recognizing to be real. There is so much room for philosophical physics in the world which experiment explores that there is a whole skyscraper above that basement where empiriological physics works so well.

ENTROPY WOULD FORBID MOTION

The law of entropy states the directionality of movement in the universe. If there is any substitute for final causality in contemporary thought, this law fills the bill. Bergson called it the most metaphysical of physical laws because it plots the course which the universe is traveling. It views the world as tumbling from less disorder to more disorder, from a less probable state to a more probable one, from thermal differences to thermal homogeneity.

But if motion is determined only by the condition that entropy increase, there are some serious difficulties that must be faced.

If entropy tells the whole story of movement, the universe would be tending to destruction rather than perfection. Entropy is the opposite of evolution, and if the two theories exist side by side, it is only because the empiriological physicist has not worried too much about consistency of concept so long as he is able to control and predict matter's activities.

Cosmic evolution and entropy truly exclude each other. The one implies a tendency to order, differentiation, and life; the other bespeaks disorder, degeneration, and death. One of these theories must be cast off if empiriological physics is to become at peace with itself. Once again, Aristotle's dualism of matter and form rises up to reconcile the opposition between entropy and cosmic progress.

But there is more to be said about entropy besides its variance with the evolutionary temper inside scientism. If cosmic motion is governed by entropy, movement is not from potency to act as in realism, but from act to potency. Act would seek to potentialize itself, order to disorganize itself, on entropic premises.

Such a view is not only inadequate as a definition of motion. It would flag motion to a complete stop. The perfect does not tend toward the imperfect but to the more perfect. A thing moves in order to acquire what it does not possess, and it would not move if all that it could seek it already owned. A cow seeks food, something that it does not have and to which it is in potency. It does not seek to be a plant since it is already a vegetative creature in so far as it is an animal. It does not seek to be a plant but to eat one. Act does not seek potency; potency seeks act. Causality on entropic premises would always be a degeneration. If empiriological physics is a science of nature, it has the world shifted into reverse, the difference between logic and ontology.

NATURE HAS A COUNTERPART TO ENTROPY

Though denying that entropy alone can account for the direction of cosmic motion, replacing final causality, the philosophy of

nature is alert to the fact that there is something like entropy in a universe that is finite. It would be strange indeed if empiriological physics, with all of its dealings in matter, did not have a dim and at least indirect grasp of truths in the speculative science of nature.

All things seek equilibrium. Unfortunately, the study of place must be reserved until Chapter 10, and it must here be taken with only promissory proof, that a body moving locally tends to its natural place and natural rest as the term of its local motion. Such an equilibrium in place, which things seek by local motion and where they tend to remain resisting outer disturbances, is viewed as disorder by the empiriological physicist. He defines equilibrium as randomness.

But in philosophical physics, as will be shown, this equilibrium in place which a nature seeks is the perfection of the moving thing. The nature asserts itself from within by preserving its identity as, say, a molecule of oxygen, against contrary forces acting from the outside. A progressively realized equilibrium would be expected if Aristotle is in general correct.

Defining order in terms of a group of particles in their interrelations rather than in terms of a nature and the fulfillment of its tendencies, the empiriological physicist inclines to conclude that equilibrium is disorder or randomness, without thinking that the individuals that make up the balance have been perfected from within by reaching a place where they can better retain their identities.

The empiriological physicist, to borrow a term from Boutroux, attains to a "mechanical equivalent" of the order which the philosophy of nature sees as the end of motion. The purpose of local movement is not disorder but the equilibrium of a moving thing with its environment. This balance is order for the nature which enjoys it since the nature can better survive and express itself. But the balance is randomness when the aggregate is viewed as a whole, without regard to the individual and intrinsic natures which only the philosophy of nature can explore.

CONTROL IS ART, NOT A SCIENCE OF NATURE

Chance, or more appropriately randomness, plays a tremendous role in empiriological physics. The empiriological physicist uses mathematics as his tool and tends to reduce nature to sheer quantity. But quantity prescinds from motion, and that is why evolution, cosmic and biological alike, is so alien to the strict equalitarian universe of experimentalism. Unable to account for origins and purposes mathematically, empiriological method goes to the concept of chance in the form of an evolutionary theory to explain the beginnings of things and to chance in the form of entropy to explain their ends. Fertility and progress, which are of nature, become impossible where sheer quantity is involved, and are attributed to disorder, since whatever is orderly must be mathematical.

Fertility and progress, the reasons which prompt empiriological method to posit chance as the ultimate are the very issues that receive a rational and realistic treatment in the philosophical science of nature, nature that is an inner principle and a source of motion. Without a philosophical science of nature, gazing on motion at its own level and not as quantity, the really big questions that fret the mind will forever remain unanswered.

All of this criticism does not deny the efficacy of empiriological physics. It only restricts the empiriological method by showing that motion, the most obvious and most important fact of direct experience, really eludes it and will continue to elude it forever. If chance is defined as the result of factors extrinsic to a given nature, it draws up alongside art, and if empiriological physics is primarily an art, it would be logical to seek a world of chance as its ideal subject matter. Both chance and art are extrinsic to nature in origin.

It ought to be expected that a discipline like empiriological physics which views matter as inert and as extrinsically determined should have hit upon chance as its foundations. The random, the indeterminate, the undifferentiated, the inert, is the controllable, and a complete control of nature would require that nature be perfectly extrinsic to itself, that natural tendencies and natural ends be repudiated, that chance be introduced as the only natural substitute for final causality, and that this chaotic world should be a nothingness so man could fashion it, creator-like, according to his own image and likeness.

The empiriological physicist may well ignore final causality to gain control of nature, and this necessarily results in putting chance at the roots of things. Once more the difference between the intrinsic and the extrinsic, finality and chance, philosophical and empiriological physics, tends to suggest the familiar distinction between art and nature. That distinction is like a master switch which beams a powerful light into many of the otherwise darkened rooms in modern methods. Philosophy does not intend to move the furniture which it sees there. It only wants to appraise it.

Suggested Readings

Aquinas, Thomas, *Summa contra gentiles,* Bk. III, chs. 1–24.

von Mises, Robert, *Probability, Statistics, and Truth* (New York, 1932).