Excerpted from "The Nature of the Physical World" by A. S. EDDINGTON

The Scientific Reaction from Microscopic Analysis

From the point of view of philosophy of science the conception associated with entropy must I think be ranked as the great contribution of the nineteenth century to scientific thought. It marked a reaction from the view that everything to which science need pay attention is discovered by a microscopic dissection of objects. It provided an alternative standpoint in which the centre of interest is shifted from the entities reached by the customary analysis (atoms, electric potentials, etc.) to qualities possessed by the system as a whole, which cannot be split up and located—a little bit here, and a little bit there. The artist desires to convey significances which cannot be told by microscopic detail and accordingly he resorts to impressionist painting. Strangely enough the physicist has found the same necessity; but his impressionist scheme is just as much exact science and even more practical in its application than his microscopic scheme.

Thus in the study of the falling stone the microscopic analysis reveals myriads of separate molecules. The energy of the stone is distributed among the molecules, the sum of the energies of the molecules making up the energy of the stone. But we cannot distribute in that way the organisation or the random element in the motions. It would be meaningless to say that a particular fraction of the organisation is located in a particular molecule.

There is one ideal of survey which would look into each minute compartment of space in turn to see what it may contain and so make what it would regard as a complete inventory of the world. But this misses any world-features which are not located in minute compartments. We often think that when we have completed our study of *one* we know all about *two*, because “two” is “one and one”. We forget that we have still to make a study of “and”. Secondary physics is the study of “and”—that is to say, of organisation.

Thanks to clear-sighted pioneers in the last century science became aware that it was missing something of practical importance by following the inventory method of the primary scheme of physics. Entropy became recognised although it was not found in any of the compartments. It was discovered and exalted because it was essential to practical applications of physics, not to satisfy any philosophic hungering. But by it science has been saved from a fatal narrowness. If we had kept entirely to the inventory method, there would have been nothing to represent “becoming” in the physical world. And science, having searched high and low, would doubtless have reported that “becoming” is an unfounded mental illusion—like beauty, life, the soul, and other things which it is unable to inventory.

I think that doubts might well have been entertained as to whether the newcomer was strictly scientific. Entropy was not in the same category as the other physical quantities recognised in science, and the extension —as we shall presently see—was in a very dangerous direction. Once you admit attributes of arrangement as subject-matter of physics, it is difficult to draw the line. But entropy had secured a firm place in physics before it was discovered that it was a measure of the random element in arrangement. It was in great favour with the engineers. Their sponsorship was the highest testimonial to its good character; because at that time it was the general

assumption that the Creation was the work of an engineer (not of a mathematician, as is the fashion nowadays).

Suppose that we were asked to arrange the following in two categories—
distance, mass, electric force, entropy, beauty, melody.

I think there are the strongest grounds for placing entropy alongside beauty and melody and not with the first three. Entropy is only found when the parts are viewed in association, and it is by viewing or hearing the parts in association that beauty and melody are discerned. All three are features of arrangement. It is a pregnant thought that one of these three associates should be able to figure as a commonplace quantity of science. The reason why this stranger can pass itself off among the aborigines of the physical world is, that it is able to speak their language, viz. the language of arithmetic. It has a measure-number associated with it and so is made quite at home in physics. Beauty and melody have not the arithmetical pass-word and so are barred out. This teaches us that what exact science looks out for is not entities of some particular category, but entities with a metrical aspect. We shall see in a later chapter that when science admits them it really admits only their metrical aspect and occupies itself solely with that. It would be no use for beauty, say, to fake up a few numerical attributes (expressing for instance the ideal proportions of symmetry) in the hope of thereby gaining admission into the portals of science and carrying on an aesthetic crusade within. It would find that the numerical aspects were duly admitted, but the aesthetic significance of them left outside. So also entropy is admitted in its numerical aspect; if it has as we faintly suspect some deeper significance touching that which appears in our consciousness as *purpose* (opposed to *chance*), that significance is left outside. These fare no worse than mass, distance, and the like which surely must have some significance beyond mere numbers; if so, that significance is lost on their incorporation into the scientific scheme—the world of shadows.

You may be inclined to regard my insistence that entropy is something excluded from the inventory of microscopic contents of the world as word-splitting. If you have all the individuals before you, their associations, arrangement and organisation are automatically before you. If you have the stars, you have the constellations. Yes; but if you have the stars, you do not take the constellations seriously. It had become the regular outlook of science, closely associated with its materialistic tendencies, that constellations are not to be taken seriously, until the constellation of entropy made a solitary exception. When we analyse the picture into a large number of particles of paint, we lose the aesthetic significance of the picture. The particles of paint go into the scientific inventory, and it is claimed that *everything that there really was* in the picture is kept. But this way of keeping a thing may be much the same as losing it. The essence of a picture (as distinct from the paint) is arrangement. Is arrangement kept or lost? The current answer seems inconsistent. In so far as arrangement signifies a picture, it is lost; science has to do with paint, not pictures. In so far as arrangement signifies organisation it is kept; science has much to do with organisation. Why should we (speaking now as philosophers, not scientists) make a discrimination between these two aspects of arrangement? The discrimination is made because the picture is no use to the scientist—he cannot get further with it. As impartial judges it is our duty to point out that likewise entropy is no use to the artist—he cannot develop his outlook with it.

I am not trying to argue that there is in the external world an objective entity which is the picture as distinct from the myriads of particles into which science has analyzed it. I doubt if the statement has any meaning; nor, if it were true, would it particularly enhance my esteem of the picture. What I would say is this: There is a side of our personality which impels us to dwell on beauty and other aesthetic significances in Nature, and in the work of man, so that our environment means to us much that is not warranted by anything found in the scientific inventory of its structure. An overwhelming feeling tells us that this is right and indispensable to the purpose of our existence. But is it rational? How can reason regard it otherwise than as a perverse misrepresentation of what is after all only a collection of atoms, aether-waves and the like, going about their business? If the physicist as advocate for reason takes this line, just whisper to him the word Entropy.