MY expression "potency for producing order" means *potential availability for the occurrence of greater order (that is, decrease of entropy) in another system.* It is no part of my business to enlighten Prof. Kapp on the principles of physical science, but I may perhaps help him by quoting a passage from the writings of a world-famous physicist[1]. "In individual sections of the universe, or in definite material systems, the movement may well be towards a higher degree of order, which is made possible because an adequate compensation occurs in some other systems. Now, according to what the physicist calls 'order', the heat stored up in the sun represents a fabulous provision for order, in so far as this heat has not yet been distributed equally over the whole universe (though its definite tendency is towards that dispersion), but is for the time being concentrated within a relatively small portion of space. The radiation of heat from the sun, of which a small portion reaches us, is the compensating process making possible the manifold forms of life and movement on the earth, which frequently present the features of increasing order."

I must apologize to Prof. Schrödinger for having attributed the expression "organized energy" to him. What he meant was, of course, that the "hot" sun and the "cool" earth represent a *non-equilibrium* distribution of energy, which makes possible the occurrence under suitable conditions of an increase of order (diminution of entropy) on the surface of our planet. It is, of course, quite true, as indicated by my expressions "potency", "potential availability", and Prof. Schrödinger's expressions "making possible", "made possible", that the purely general thermodynamic argument provides only a *conditio sine qua non*, that is, a necessary but not a necessary and sufficient condition. It is this gap which affords a loophole for the metaphysicians (including metaphysically minded engineers), to insert their "entelechies" and "specifications", which are obviously nothing else than words inserted into the description for the purpose of satisfying the personal wish for a mystical element of "causality".

Science, as is seen in the work of the photochemists, biochemists and physiologists, does not proceed in this manner, but endeavours to fill the gap between necessary and sufficient by patient and detailed experimental investigation. I think it would do Prof. Kapp a great deal of good if he could spend some of his spare time in the study of photochemistry and photosynthesis. He would be surprised to find that the relatively high-frequency photons which enter the green leaf do not "kick" the "nuts and bolts" about after the fashion of the mad engineer depicted in his letter. That dramatic scene provides us indeed with a very revealing picture of Prof. Kapp's conceptual "chaos". On the contrary, he would find that the available energy of the "non-equilibrium" photons is largely utilized, by means of the leaf pigments and an enzymatic system, in producing a greater degree of order, not of disorder.

Finally, let me say, as I briefly indicated in my review, that I do not wish to deny that biological science may or will require for its more highly developed autonomous description concepts, methods of thought, and mathematical techniques which are unknown (or at least very unfamiliar and unusual) in present-day physics and chemistry. It may be necessary, for example, to distinguish between the biological concept of 'organization' and the physical concept of 'order', perhaps defining the former as a capability for producing order *for an end*. Needless to say, the teleological or finalistic element in such a definition has been anathema in physical science since the days of the Renaissance and the breakaway from medieval Aristotelian scholasticism. But an autonomous description of biological phenomena amounts to the assumption that such a description will be different in some respects in type from that hitherto found suitable for physical science. If so, it will require an appropriate mathematical technique or a method of symbolic logic involving some sort of 'dimensional' extension in its system of relationships. Its system of causation will differ from the probability-distributions of modern quantum theory, perhaps by a suitable modification of the latter by means of Volterra functionals of the historical type.

I do not think that Admiral Beadnell need have any fear that my use of the adjective 'non-material', *as applied to radiation*, will be a source of any comfort to the 'metaphysicians', for, in the sense in which I used it, non-material means 'not having the same properties as matter', but at the same time something quite as real. He is quite right, however, in pointing out that this use of the adjective non-material is inconsistent with the use of the same adjective as applied to Prof. Kapp's "specification", where it means unreal, in the sense of being derived *a priori* from the dialectic of metaphysical 'idealism'.

The complementary aspects of the descriptions, namely, 'wave-like' and 'particle-like', of the behaviour of both radiation and matter in different experimental conditions were very puzzling at one time, but I think I am correct in stating that modern quantum and quantum-statistical theory has found a consistent method of predicting the macroscopic results of all such experiments without involving the assumption that matter and radiation are synonymous terms. I think that if Admiral Beadnell will refer to Heitler's recent book on the quantum theory of radiation, he will obtain a definite answer to his question such as I am not competent to give. I wish to thank him for his friendly comment and his kindly reference to my review of Prof. Kapp's book.

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[1] "Science and the Human Temperament", by E. Schrödinger. Translated by James Murphy. (London, George Allen and Unwin, Ltd., 1935.) The passage quoted occurs on pp. 39 and 40.

Optical Images formed by Conical Refraction

A PLATE of biaxial crystal cut approximately normal to the axis of single-ray velocity has the remarkable property of forming optical images of an illuminated object held in front of it. This effect was first observed with aragonite[1] but is exhibited in a much more striking fashion by a plate of naphthalene prepared for the exhibition of conical refraction as described in a recent note[2]. The accompanying reproduction illustrates this phenomenon. 1 and 3 reproduce objects held in front of the crystal, while 2 and 4 are the corresponding images formed in the rear of the crystal and received directly on a photographic plate. The image recorded is in every case erect and of unit magnification. The distances of the object and of the image from the crystal faces may be independently varied from zero up to large values.