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METAPHYSICS AND SCIENCE

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CONTENTS

Why is science inescapably bound up with metaphysics ? I will try to answer this question by a close examination of the nature of scientific thought and of the structure of its products. I will be looking not only at the logical structure of scientific discourse, but also at the organisational principles of its content. It is now clear that elucidating only the logical structure of a discourse is quite inadequate for philosophical purposes since most of the distinctions one wants to make, such as that between law and universal generalization, are not expressible in differences in logical form.

I

Kantian philosophy of science had its *debut* in England in the lectures of 1818by S. T. Coleridge. His fame as a poet has tended to obscure the importance of his influence as a philosopher of science,

particularly through his close association with Humphrey Davy. It would not be inaccurate to say that he prepared the way for Whewell, whose generally Kantian ideas about science, both strengthened Faraday's own ideas and influenced his later development, particularly the theory of fields. Coleridge contributed two main ideas to English thought. He provided a spectacular and powerful impetus to the native tradition of dynamism, the world theory opposed to matterism that so strongly influenced English physics. According to dynamism, the world was a structure of forces and powers, not a swarm of lumps of inert matter. Coleridge's critique of matter as the fundamental stuff of the universe reinforced the existing theories of Michell and Priestley; but more importantly for the purposes of this paper, he laid particular stress both in his theory of poetry and in his theory of science, on the central rôle of the imagination.

In the imagination we conceive the reality we cannot perceive. And just as there are two realms of the imperceptible, that which we *might* or *could* perceive were its consistuent things larger and its processes happening more slowly, and that which we never could perceive since it lacks any perceptible qualities, so, according to Coleridge, there are two phases of activity of the imagination. There is that in which all possible perceptions are anticipated. This is the primary imagination, "the living power and prime agent of all human perception". The very small, very fast, very cold, very large, very slow or very quiet, and so on, can be conceived by the exercise of this kind of imagination. They are conceived in a mode in which we might perceive them could our senses be extended. If we imagine things merely in the mode of perception, this is the work of Fancy which "has no other counters to play with, but fixities and definites. The Fancy is, indeed, no other than a mode of memory emancipated from the order of time and space... but equally with the ordinary memory, the Fancy must receive all its materials ready-made from the law of association". (Coleridge, *Biographia Literaria*, Ch. XIII). But the imagination has a second phase in which, transcending all possible perception, it enables us to conceive of a world whose elements would be for ever imperceptible. How is this second phase possible ? In what form can the imagination produce an image of the imperceptible ? This is the secondary imagination, conceived by Coleridge to be an echo of the primary imagination. "It dissolves, diffuses, dissipates, in order to recreate. Or where this process is rendered impossible, it still, at all events, struggles to idealize and to unify. It is essentially *vital* ..." To see what the secondary imagination must be able to do we must ask why an object would be

imperceptible. Clearly one condition for imperceptibility would be that the causal powers of the object acted remotely, affecting first an intermediate entity which would be perceptible. This is particularly the case for those entities we speak of detecting (the magnetic field, a dark star) rather than observing (the deflection of the galvanometer, the Jovian satellites). The object itself is a structure of elements, but since the elements are imperceptible, so is the structure. But clearly, by concrete imagination, we can represent the structure as a relation among the imagined elements.

But what effect does the imagining of abstract form in concrete structures have upon those forms? Maxwell, a great adept at the art of concrete representation, is responsible for the idea that the concrete form imposes the same degree of consistency upon that which it represents, as it has itself. A mechanical model of the ether, for example, would be a form of consistent representation for the imperceptible structure of unimaginable elements, the field potentials. And since the form of representation must be structurally isomorphic with what it represents, it imposes upon the imperceptible structure the degree of spatio-temporal reality it itself possesses. Thus, a three-dimensional structure evolving over time is plausible as a reality without further dispute, while a four-dimensional structure so evolving is not. Of course, considerations in favour of the latter might be advanced, but these would involve fundamental questions of the nature of reality not raised by the postulation of a structure isomorphic with the structures of our experience.

Such an idea is created by the work of the imagination, which is "that reconciling and mediating power which, incorporating the reason in the images of the sense and organizing (as it were) the flux of the senses by the permanence and self-circling energies of the reason, gives birth to a system of symbols harmonious in themselves and con-substantial with the truths of which they are the conductors". (Coleridge, *Complete Works*, I, 436). True creativity is to be found in work of the secondary phase of the imagination. The Fancy merely pushes back the contingently placed barriers to actual perception. "Fancy", says Barfield, "is the aggregating power. It combines an aggregate's given units of an already conscious experience, whereas the secondary imagination 'modifies' the units themselves". (Barfield, 1972).

II

But why are we driven to these excesses of the imagination ? The pressure to try to conceive of the world beyond experience comes directly from the isomorphism of structure between the content of causal propositions and the form of scientific explanations. Let us first examine causal propositions.

A proposition is presented to us as a putative causal proposition when it describes a generative process in terms of its productive conditions and their outcome. Such a proposition must fulfil two criteria :

i) It must be capable of being augmented *a posteriori* until it refers to a natural agent with a disposition to produce the effect or outcome referred to in the original proposition.

ii) It must be capable of impoverishment *a priori* until the causal conditions are referred to by a description conceptually (and hence logically) independent of the description of the effect.

Thus the putative causal proposition

"The liquid corroded the metal" (1)

can be augmented *a posteriori* by empirical study of the liquid to give :

"The liquid containing an acid, corroded the metal", (2)

where, the meaning of "acid" includes being "corrosive", reflecting the natural necessity of the corrosive action of acids. Proposition (1) can be impoverished to,

"The corrosive liquid was present with the corroded metal" (3)

which by logical reasoning entails,

"The liquid was present with the corroded metal" (4)

in which the bare description "liquid" is logically independent of the predicate "corroded metal" in a way that "acid" is not independent of "corrosive liquid".

If augmentation cannot be achieved, the proposition is probably not causal but either describes a coincidence or the co-occurrence of the effects of a common cause.

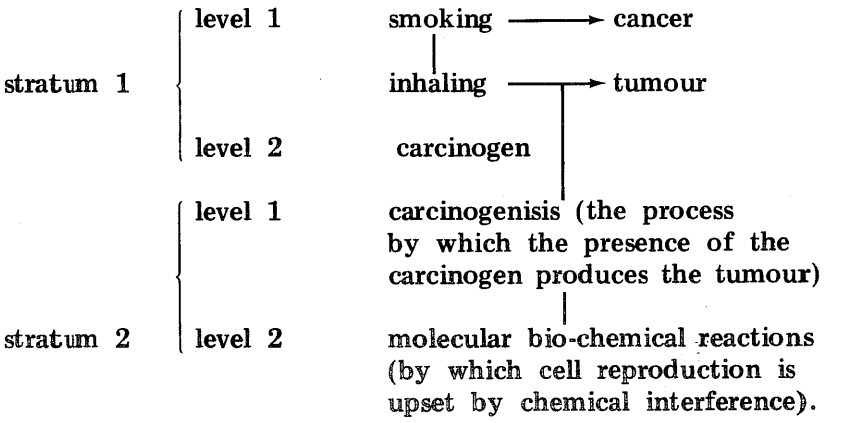
If impoverishment cannot be achieved, the proposition is probably not causal, being a definitional tautology. Thus any empirical proposition which refers to a natural agent is certainly causal. A causal proposition not only describes the conditions and the effect, but if we take it to be *causal* it carries the implication that there exists an agent capable of producing or generating the effect. The agent may be a singular potent substance (an acid) or a complex mechanism (the clockwork).

In a scientific investigation the next question would be, "What is it

about an acid that endows it with the disposition, the power, to corrode? " Its "corrosiveness" is no answer. What is wanted is the mechanism of the process of corrosion and that leads directly to the investigation of the intrinsic nature of acids.

The fact that causal propositions often need to be augmented to reveal their referential commitment to a causal agent or natural power, shows that there is at least an epistemological distinction to be drawn between the cause as initially described, say "smoking", and the cause as described in the augmented description, "inhaling carcinogens produced by burning tabacco". That is, one can discover that smoking causes cancer without knowing which natural agent is present in tobacco smoke, to generate or produce the effect. There is, in general, a metaphysical distinction between the *process* or *event* which always or usually antedates the effect, and the *natural agent* or *causal power* which produces that effect, since the agent is a persisting *thing* or *substance* (a material cause) having a definite *structure*. The structure is frequently a synchronic template from which the diachronic process of production of the effect takes its form. Frequently, if what is produced is another object as in organic reproduction, the structure of that object is a mapping of the structure of the natural agent, as the anatomy of a plant or animal is a mapping of the structure of the genetic material.

Thus the implicit character of the reference to agents, the epistemological distance of those agents from the initial identified causal conditions, and the metaphysical distinction between processes and things, all encourage one to adopt a stratified scheme for analysing causal discourse.



Level 2 is called into being by augmentation of level 1 and stratum 2 by the necessity to augment to propositions ascribing causal powers to the agent identified during the augmentation. We notice too that the structure is bound together by conceptual necessity since a "carcinogen" is a substance which tends to produce tumours, a tendency which, of course, may not be released in action. The necessity to augment the descriptions of causes drives an investigation towards the empirically unknown and the metaphysically remote.

The same structure is found if we analyse the content of a scientific explanation. Indeed, one can hardly conceal the fact that an augmented causal proposition is no less than a scientific explanation of the phenomenon described in the initial diminished form of the proposition. In the initial stratum a pattern of phenomena, for example the distribution of characteristics from one generation to another, or the hexagon structure of snowflakes, is described, and in the second level of that stratum, natural agents (genes and so on) or generative mechanisms (the packing properties of spherules) are adduced to explain the patterns. But the behaviour of the entities of the second level are themselves unexplained patterns of behaviour for the first level of a second stratum in whose second level they are explained. And just as in the augmentation of causal propositions the things, properties and processes referred to in the second levels of strata, are not, initially, open to the same kind of empirical investigation as the patterns in the first levels. Nor are the things and processes in the second, third etc. strata in the same arena of experience as the patterns of the first.

The direction of the development of scientific explanation is very clear. They always lead beyond any actual experience, first into strata of possible experience made actual by microscopes, stethoscopes, slow motion film, etc., and then, very quickly, into realms beyond all possible experience where objects of unimaginable natures (electrons, fields, charges etc.) are known to us only by those of their powers which are manifested in the reaction of things which happen to be in a stratum of nature of which we have experience.

III

The pressure to pass beyond experience is exemplified by yet another isomorph of the dual structure we have identified in causal propositions and in the schema of the scientific explanation, an isomorph which is present throughout science. During most of our

intellectual history philosophers have tended to employ three basic categories in their analyses of the things we experience - substance, quality and event. Different ontologies derive from the assignment of differing priorities in being, or knowledge, or both, amongst the three. Materialism takes "substance" as prior, and "quality" and "event" as dependent in being, "event" being "change in quality". Phenomenalism takes "quality" as the independent member, things (individual substances) being sets of co-existing qualities or sets of successive events. Sometimes, "event" is assigned priority.

It has only recently been borne in upon philosophers that the natural sciences have never really used this categorial system though they have often been reinterpreted as if they did. It has long been apparent that the category of substance is fraught with difficulty when it is used non-relatively; by that I mean independent of all qualitative differentiation. Thus the material, brass, can be distinguished from the form, monkey, and even from the colour, gold, since the gold brass monkey, can be hammered into the shape of a dog, and allowed to corrode to a brownish patina. The substance which is independent of all qualities seems hard to come by. As a metaphysical or ultimate category we seem left only with quality, changes in which are events.

But quality too seems difficult to sustain as a non-relative category, since the quality one attributes seems to be dependent upon accidental properties of the observer or detector, such as its sensitivity to particular bands of the electromagnetic spectrum, and upon contingencies in the environment, such as enough light. Witness Thurber's problem of a nasty thing "that would have been purple had there been any light to see it by". What then, are we to make of attributions like colour, warmth, electric charge, shape, weight and so on, as properties of things ?

A scientific solution is to distinguish between the thing's or individual's powers and liabilities and its nature. In attributing a power or liability to an individual, we are saying what effects it is likely to produce, or what effects will be produced in it by the powers of other things. But an individual has its powers and liabilities all the time, whether they are being exercised or not, so those powers must be rooted in some permanent but generally unmanifested features, its nature. We are entitled to speak of those features as the nature of a thing since its criteria of differentiation, individuation and identification derive from them. An acid has the power to form salts with bases and this power is grounded in the nature of acids, that is, it belongs to those substances which contain hydrogen ions. A charged body has the power to affect an electroscope and that

power is grounded in the nature of electric charge. In the acid example, we know what is the feature of the nature of acids that grounds the power and makes it a power of the acid, while in the electric charge case we do not. This illustrates the point that the grounding of a power attribution in a feature of a nature may be unspecified and hypothetical, awaiting further *a posteriori* study of the individuals involved.

The Powers/Nature formula is, then, isomorphic with both the implicit structure of causal propositions and with the form of explanatory schemata, in that a behavioural or dispositional clause

"In circumstances *C*, individual of kind *K* would do *B* ..."

is conjoined with a nature clause

" ... in virtue of the nature *N* of that individual"

where the features of *N* not only explain the behaviour *B*, but also explain why the criterion for the kind *K* is what it is. Epistemologically the isomorphism is equally striking since initially, the behaviour *B* is better known than the nature *N* which will be subject to further *a posteriori* empirical study, until beyond the boundary of all possible experience plausible invention takes over.

Adopting the scientific or Powers / Nature categorial scheme rather than that traditional extension of common-sense the Substance/Quality scheme, again drives one into the attempt to imagine the world beyond experience, where only metaphysical theories can be our guide. But the passage from behaviours to natures is marked by one fairly substantial guiding principle which has been a mark of science since antiquity. The preferred form for a nature is a structure of elementary agents, a structure and its differentiations taking over the explanation of the diversity of qualities. The spectrum from solid through liquid to gaseous, for example, is a three-fold, qualitative differentiation, and is replaced by differential forms of integrity of structure of the same molecular constituents of the material which passes through the three phases. The one hundred chemical elements become one hundred different structures of three main elementary electrical constituents. Quality is everywhere replaced by power, qualitative differentiation by structural diversity.

Sub-conclusion

Causal laws, explanatory schema and the descriptive categories of science all tend to force the development of conceptions of the structure and elements of the world beyond all possible experience. So theories of any degree of sophistication contain terms which refer

to putative real entities for which there could be no possible experiential test. (Harré, 1972).

IV

How, then, are our ideas of the world beyond experience to be justified? Positivism has a very short answer. Only experience can provide justification, so the world beyond experience can play no part in the ontology of science. Hence, for positivists, causal laws are single-level statements of regularity of precedence and co-existence of experiences, explanation is formal assumption under a general law, and the only admissible descriptive category is quality, out of which things as sets of qualities and events as changes in qualities are derived. But as I have shown, the structure of science is not positivistic. We are then faced, if we wish to preserve the structure of science, with the problem of justifying our ideas of the nature of the world beyond all possible experience. Moreover, the problem is as much present in psychology as it is in physics. Our efforts to understand the way people interact in small scale social encounters involves the three isomorphic schemata of causation, explanation and powers, just as much as does our efforts to understand the genesis and transmission of light. This can be seen most clearly if we look at the structure of Goffman's widely admired theory of the way people maintain a coherent social "face" in many real life situations. In Goffman's theory (Goffman, 1969) character is presented not so much in what actions are performed, but in the manner of doing them; thus persona and character words appear as adverbial qualifications of action verbs : "He counted up the money sullenly", "He thanked her formally", etc., from which we create persons or character "attributions" as a "sullen sort of man", a "very formal type", and so on. According to Goffman, much of the way doctors, waiters, and indeed anyone presenting a recognisable style in public, can best be understood, is according to a dramaturgical model. In this model, the physical space of the action is divided up into front stage (the doctor's surgery), back stage (his private room), the people involved are divided into his "team" or supporting cast, who contribute to his impression management (his nurse, receptionist, etc.), and the audience (the patience, or clientele) for whom the impression is managed and the persona presented.

It is obvious that there are varying degrees of self-consciousness possible in the people whose behaviour is analysed under this model. Goffman presents examples to show that people can and do distance

themselves from and sometimes consciously control their manner of acting in managing the impression they are creating. One of these is what he calls "rôle-distance". In taking rôle-distance a person allows it to be seen that he is aware of the mode of acting in which the major or dominant persona of the occasion is presented, and, for the achievement of various micro-sociological ends, shows himself to be not wholly serious in his rôle performance, as "great surgeon" or whatever. In taking rôle-distance, self-consciousness has not reached that degree in which action becomes a wooden, false or inhibited.

Considered phenomenologically and as an empirical matter, the processes of action-genesis and its control, identified by Goffman, show a familiar form, the "fleeing self" of Hume. As each point of view becomes an object, so that which has that point of view flees to another fulcrum. We are obliged, then, to see the self-perception of one's own action and its genesis as having the familiar stratified form. Hume's response to the fleeing ego was to deny the self as an empirical concept. Our response is to utilize the familiar strategy of realist natural science and to attempt the construction of icons of the unknowable centre of the self. I have argued elsewhere that no one model drawn from other experience can serve to represent the self (Harré and Secord, 1972). An ensemble of models involving at least two distinct sources is required, each source corresponding to a route to knowledge of a person. There is the route through common-sense knowledge of ourselves, the models which appear in such conceptions as Freud's generalizations of commonsense. There is the route through physiology, leading to models of the functioning of the brain, the route of such workers as Luria. This route is much more hazardous than appears at first sight, since in certain specific areas such as the study of the emotions, it has been shown that the apparently independent physiological model is heavily dependent on an imagery and symbolism of the self, which can be explicated only in an historical ethnography of European theories of the person (cf. Averill, 1974 and his studies of psychological symbolism). Models derived from following the first route develop on the basis of generally psychical concepts, those of the second on a complex mix of traditional symbolism with biochemical and biophysical concepts. Finally one should mention the interesting intermediary type of icon — the cybernetic — which tends to be an idealization of ideational and generally psychic conceptions of thought processes, modified by *a priori* assumptions about the kind of physical entity a functioning brain might be, the latter filtered through changing current ideas as to the possibility of constructing surrogate mechanisms which will be functionally equivalent to the active brain. I do not believe

cybernetic modelling is a third route to icons of the inexperiencable self, but rather an attempt to use cybernetic concepts as constraints in the developing of a mixed model, drawing upon both commonsense,psychic conceptions and physiological ideas. I would like to follow Bunge at this point (Bunge 1974) in his claim that generalized abstract engineering principles from which cybernetic models take their characteristic blend of the psychic and the physiological are to be treated as metaphysical principles.

It should also be plain that a final analysis of human functioning in terms of powers or grounded dispositions, leads to an isomorph of a stratified icon of the self that comes from following the fleeing ego. A power, say, to produce an acceptable justificatory discourse, is grounded in a structural property of a person, say the total Markov Maze of possible sentences, through the choice modes of which our talker passed, choosing one route in the discourse rather than another, rejecting one way of putting his point by quick reference to the possible consequential reactions of his audience and so on. The power to construct and decide among possible forms of speech is consequential on a more fundamental and more permanent structural property of a person than the ephemeral structure which is created to be the basis of a discourse. One icon of this structure may be said to be a conception of his nature, say as represented in a Kelly repertory grid. The grid expresses the actual relationships between a set of items, fundamental units or elements of meaning, of course, *internally* related to others in semantic fields, which are this person's conceptual, linguistic, etc. resources and represent his competence as social actor or speaker. We are thus presented with the familiar Powers/Nature, Powers/Nature, Powers, analytical form. It remains simply to remark that explanation of human action can be achieved by constructing a discourse following either route.

But there is yet another issue, predetermined before the acknowledgment of the legitimacy of all such processes as I have just described — the issue of the relation of a person's actions to his environment, the issue of his agency or passivity. The most extreme statement of the passivity theory is that of Skinner (1972), but though the theory may not be expressedly acknowledged by other psychologists, nevertheless, it is implicit in their practice, both in the idea of "experiment" and in the idea of "behaviour modification". It is, of course, a metaphysical theory, as is evident in the way Skinnerians continually broaden their concepts to include cases which might count against passive environmentalism. The theory involves only three basic concepts - the environment which provides "reinforcement" and "control", and the "operant", spontaneously

emitted behaviour which is differentially selected by reinforcement, thus leading to control. The basic theory involved is an extreme environmentalism, all creative processes, the genesis of action by an individual, being denied efficacy in the production of action.

Three signs or marks of the metaphysical character of this point of view can be sidcerned.

i) The Kantian point, that the environment for people is in part a product of human understanding, and must be treated as endowed with meaning by human thought, is simply ignored.

ii) The obvious fact that much human activity is controlled not by the environment but in spite of it, by internal cogitation, planning, etc., leads to the move of weakening the concept of environmental control to merely the once-effective environment in reinforcing self-control, or the fatal move of extending the concept to cover the 'internal' environment as well.

iii) The categorial difference between speech and emitting sound is denied, to be replaced by systematic elimination of the notion of understanding to such an extent that even science is reconstrued as the verbal behaviours emitted by scientists under the control of the laboratory environment.

We thus have three characteristic marks of a metaphysical or concept-producing theory. Only phenomena intelligible within it are admitted to exist. All phenomena admitted to exist are brought under the concept including those originally excluded, thus weakening the concept so that it includes its contrary. And finally, all categorial differences originally required in the description and classification of phenomena, before the advent of the theory, are eliminated by reconstruing dichotomies as monotype variations of that one of the original exclusive dichotomous concepts which belongs to the new theory. Such a theory determines an ontology and settles in advance both the conceptual organisation of the phenomena admitted in that ontology and the concepts involved in their organisation.

The acceptability of a metaphysical scheme such as Skinner's and that implicit in experimental psychology rests not on empirical test, for only detailed hypotheses within this scheme can be tested, but on the range and centrality of the phenomena and concepts excluded from consideration as such. On these grounds, the Skinnerian metaphysics must be wholly rejected since most human activity is excluded from consideration *as such*. (For a detailed examination of the scheme implicit in experimental psychology one could consult Harré and Secord (1972), and Chomsky (1965) for an examination of Skinner's explicit statement of the theory). Skinner's scheme is

not objectionable *because* it is metaphysics — far from it. It is only as such that it commands our serious attention, for it determines in advance the form of the icons we can conceive, the structures and processes in the unknowable centre of human action.

The transcendence of experience can be achieved only by reason. The work of reason in the development of the deeper strata of science is concerned with disciplining the imagination of scientists, in which ideas which represent the structure and powers of the individuals that make up the real world are produced. That work is metaphysical since metaphysical investigations are concerned with showing both that a certain conception of the world is coherent and that it represents the necessary conditions for the possibility of experience. It is, of course, impossible to show by any form of reason that a conception which represents a form and state of the world beyond experience is a sufficient condition for our actual experience. Thus, though we can show that without p, q would not be possible, it does not follow that the occurrence of the state of affairs described in p is sufficient to bring about q.

There have been four major metaphysical schemes to date in science — that of Aristotle, the Corpuscularian philosophy, the Theory of Fluids or the Plenum, and the Theory of Fields. Each of these has been combined in various ways with metaphysical theories of space and time. The enormous number of possible images of the real world beyond experience can be ordered by examining the options that are available for conceiving of material stuff and of the nature of individuals. Only some choices of options can be combined into consistent images and this will be shown by the critical application of reason to the description of an image of the real world. Finally, a still more limited set of possible images emerges from a location of a theory of the real world within the various possible, transcendental specifications of space and time, the causally inert relations between individuals and between their changing properties.

There are three major components of a system of thought that will generate conceptions of the world. There must be a theory of individuals, a theory of causality and a theory of space and time. Various very fundamental principles link the three components into specifications of a world. For example, the principle that no two individuals may be in the same place at the same time interconnects the first and last, while the principle that nothing can be generated from nothing interconnects the first and second. The principle that causes are simultaneous with or prior to their effects interconnects

causality and time, while the principle of local action interconnects causality and space.

Dichotomies look attractive on the page, so I shall try to locate different conceptual alternatives under the three fundamental categories in a series of binary oppositions. Individuals can be conceived under either of several dichotomies. They can be regarded as sources of spontaneous action (agents) or the subject or bearers of action (patients). They can be conceived as permanent and indestructible, or evanescent. They can be regarded as simple or complex, as externally or internally related one with another. Generally, the following combinations of oppositions have been assumed to be the basis of consistent images of the world.

1. Atomism : Individuals are simple, indestructible, passive and independent.
2. Dynamism : Individuals are simple, evanescent, active and interdependent.

In general, indestructibility and independence are supposed to go together, while interdependence seems to be naturally taken to imply a more fragile mode of being.

Looked at with respect to their relations to space and time, we find that the individuals of atomism occupy all of time (being indestructible) and only part of space, while the individuals of dynamism tend to be regarded via the consequences of their interdependence (acting where they are not) to occupy all of space, but only parts of time. In the grand opposition between time theories, between block universes and universes of genuine becoming, the Laplacian atomism of perfect determinism seems the natural form for a block universe to take, while the melting, reforming and everchanging individuals of the dynamic point of view seem to be the natural media of becoming.

There have been exceptional intermediate views, the viability of which takes away somewhat from the air of necessity with which I have tried to invest the leading contenders. Boscovich and Kant, for example, while expounding a thoroughgoing dynamism, regarded the individuals at the point centres of activity, as permanent indestructible 'atoms'. And Leibniz supposed his monads to reflect internally all possible states of the world, so that they would unfold inexorably in a way reminiscent of the Laplacian block. Further very detailed investigation would be required to adjudicate on the strength and kind of necessity that attended any of the cross connections I have pointed out.

There have been general theories of the things and processes behind the patterns of experience but space and time, the abstract

non-causal relations between the things both within and behind experience, are also liable to the distinction between their overt and their transcendental properties. From a mathematical point of view, space and time, the system of the possibilities of existence, could each have one of three possible structures. Spatial or temporal intervals could be sets of points of the order of the real numbers, of the rationals, or finite sets of discrete points. There are three main philosophical issues which have to be settled to determine a realist theory of space and time.

1. How far can empirical studies guide us in ascribing a structure to space or time ?
2. What constraints are there on the possibility of spatio-temporal systems ?
3. Are all the instants of time and points of space given in advance of their occurrence or their occupation, or is there a real becoming in time and a corresponding genesis of space ?

The first question can be answered fairly readily from elementary mathematical considerations. Our conception of the structuring of space and time derives from the processes of division executed on phenomenal continua. There are also indirect processes of division executed through causal principles. There are arguments that the limitations on these processes that follow from the quantisation of energy requires us to postulate a granulatory of space and time, with hodons and cronons as minimal divisions, but I shall not further pursue this here. So far as we can currently determine, direct division can be continued indefinitely so that for any actual decomposition there are finitely many parts but there is no reason to suppose further steps of division could not occur. Which of the three possible structures does this favour ? We know that sets of points of the order of the real numbers cannot be generated by indefinitely prolonged division but that that is a standard method for generating sets of the order of the rationals. And since we can conceive no obstruction to further division in principle from any degree of decomposition we may have already achieved, any hypothesis that a currently available finite set of points is a real structure of spatial or temporal intervals, can be refuted in principle. The hypothesis that spatial and temporal intervals are sets of points of the order of the rationals is then the simplest available hypothesis. But there are mathematical reasons for supposing that sets of points and instants are of the order of the real numbers, e.g. that a kinematic function should be continuous, differentiable at all points. But, if impressed by these considerations, we assign the order of the real numbers to the set of points in spatial and temporal intervals, that assignment is

transcendental, going beyond all possible experience and its generalisation.

To answer the second question we must examine the various possible cross-combinations of possible spaces and times : (1) Real space, discrete time; (2) Real space, rational time; (3) Rational space, discrete time; (4) Rational space, real time; (5) Real space, real time; (6) Rational space, rational time; (7) Discrete space, discrete time; (8) Discrete space, rational time; (9) Discrete space, real time.

These can be categorised as :

(a) Disparate combinations (Space richer than time) (1),(2),(3).
(b) Disparate combinations (Time richer than space) (4),(8),(9).
(c) Matching combinations (5),(6),(7).

Provided that there are exactly as many points of space as there are instants of time in each interval, the motion of a real body is possible in the discrete spatio-temporal system, so that with that proviso and since real sets can be matched with real and rational with rational, all the combinations in category (c) are possible real structures, though as we have pointed out, general empirical considerations would tend to favour the non-discrete combination.

Systems in category (a) are such that there are spatial points to which they are no corresponding times, that is possible venues for a real thing but no instant for which it could occupy that place. This renders the concept of continuity of existence of a real being problematic. If those points without instances are members of a trajectory, the path of the real moving body is paradoxical since the body will never be present in those places though it will be at all other points in the trajectory. On the other hand, systems of category (b), involve times at which a moving real body might exist, but there would be no places for it to be at those times. If the given places are points which are members of a set making up a trajectory, part of the life of the body must be spent "out of space", or alternatively there must be times at which it does not exist.

Provided, then, we aim to preserve the conceptual structure of the concept of material existence, that is, spatial occupancy for a time, the disparate combinations can be ruled out *a priori*.

These arguments are certainly not enough to establish transcendental properties for space and time adequate for modern physics. The form of representation established so far allows a wide variety of symmetries, wider than we may find necessary for physics. For example, the transcendental properties of time relative to Newtonian physics include the symmetry that -t may be substituted for t in all the laws of nature without altering their forms. In two cases in modern physics it seems plausible to deny this symmetry to

Time. The Charge-Parity-Time relations seem to require the transcendental symmetries of the space and time systems to be non-independent, and strongly suggest the view that charge should be included in the spatial or spatio-temporal symmetries, so that CPT conservation could be seen as the empirical consequence of certain transcendental symmetry properties of the joint system of Space/Time. Thermodynamics would rest more confortably on a temporal system which did not possess t/-t symmetry as a transcendental property. By ascribing these properties to the transcendental system of Space/Time, the form of thermodynamic and microphysical laws no longer derives from *ad hoc* restrictions such as CPT conservation and the 'laws' of entropy, but from the properties of the Space/Time system, which can then be developed as a systematic, transcendental theory by mathematicians.

Finally, one should notice that in a micro-interaction, time is continuous in the Schrödinger equation for each interactant, and because of the principle of linear superposition of wave functions, it is also continuous for the joint system. But when an experimental physicist has to bring two 'particles' together experimentally, the Energy/Time uncertainty relation requires that the time of the interaction cannot be sharp. It is certainly not a Dedekind cut in a *continuum.* Whether this and similar features of modern physics ought, like symmetry, to be fed back into the transcendental properties of Space/Time is arguable. The Schrödinger equation assumes a time parameter that is continuous and real, but under that interpretation the Energy/Time uncertainty relation is reduced to an *ad hoc* principle and does not follow as a necessary consequence of the transcendental properties of Space/Time.

It seems that the arguments of this paper suggest a complex but manageable conclusion. The three epistemologically distinct realms, that of ordinary experience, Realm I; of possible experience, Realm II; and the realm beyond all possible experience, Realm III, require three ontologies. The ontologies of Realm I and Realm II are related conceptually

(i) as concrete and and abstract versions of the Substance/Quality ontology,
(ii) by the theory of primary and secondary qualities, and empirically by
(iii) the Powers/Natures relation which is represented conceptually in
(iv) the observed pattern/generative mechanism structure of scientific explanation.

But in the ontology of Realm III the Substance/Quality metaphysics has been entirely superseded by the Powers/Natures

system in a completely abstract form requiring mathematical expression.

Finally, in this paper, I want to address the problem of whether there is a common feature of the three ontologies on the basis of which *the* system can be erected. The first point to notice is the mutuality between a 'powers' description of a world and a 'structures' description. To attribute a power to a location is to ascribe an ability to produce an effect elsewhere in space or time, or a liability to suffer an effect from elsewhere in space or time. To attribute powers (and liabilities) to locations is then to ascribe a network of latent and manifest causal interrelations to a multiplicity of locations. If, instead of concentrating upon the nodes of this network, we turn our attention to the latent and manifest causal relations between the nodes, we find ourselves describing that world as a set of possible and actual structures. By the addition of one or more invariants to the description, and specifying the boundary conditions, we reach the specification of a 'system'. For my purpose in this paper, I want to emphasize only the fundamental point that one can always describe a world either with power concepts or with structure concepts, provided the structures ascribed to the world include both latent and manifest structures.

To identify the common features of all three ontologies, one must look closely at the conceptual system by which their realms are linked — that is, at the inter-related Powers/Natures concepts. According to that system, the assertion that an individual has a certain observable quality or detectable property is to be treated for scientific purposes as the assertion that the individual has a nature, such that it has the power to produce that experience in a person in suitable circumstances, or to produce a reaction in an instrument of appropriate design. The power is defined with respect to the empirical concept associated with the experience or reaction, that is, as 'the power to look red' or 'to set a galvanometer twitching'. No advance in understanding will have been achieved, as I showed earlier in this paper, unless the nature is specified according to a new set of individuals and the relations between them. Because this set of individuals must constitute the original individuals the relations must be bound by some invariant or invariants, thus constituting a system. It follows that diversity of determinate qualities in a kind of individual, as it is experienced, must be explained as a multiplicity of structures in the natures of those individuals. Provided the natures of experienceable individuals are still within the reach of possible experience, the new individuals, which are the nodes of the inner (or outer, e.g. galaxies) structure of the original individuals, must retain a

certain subset of properties of the ensemble of properties that defined the original individual. The generalisation of this scheme to the world beyond all possible experience leaves us with structures whose representation is mathematical, whose conception is by abstraction from all possible experienceable qualities, and whose nodes must therefore be conceived either as pure powers, or further structures of pure powers. Laying out the matter this way, it becomes clear that the only feature which links the *three* ontologies is structure, since the primary and secondary quality theory which links the first and second ontology, those of the worlds of actual and possible experience, cannot serve to connect either world with the world beyond all possible experience.

The above analyse can be condensed into two principles :

1. Whatever is a structure in Realm I must be a structure in Realm II and Realm III.
2. Whatever is a quality of an individual in Realm I is either a quality of an individual in Realm II or a structure of individuals in Realm II, and whatever is a quality of an individual in Realm II or a structure of individuals in Realm II is a structure of individuals in Realm III.

Conclusion

Thus, a universal materialist ontology must take structure (or the complementary notion of power) as its fundamental category, having transcended the intermediate stage of a matter-based system, be that matter conceived to be in atomic units or continuous media.

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