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# Causal Laws and Singular Causation

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In this paper it will be argued that causal laws describe the actions of causal powers. The process which results from such an action is one which belongs to a natural kind, the essence of which is that it is a display of this causal power. Therefore, if anything has a given causal power necessarily, it must be naturally disposed to act in the manner prescribed by the causal law describing the action of this causal power. In the formal expressions of causal laws, the necessity operators occur within the scopes of the universal quantifiers. Hence the necessities must hold of each instance. The causal laws may thus be shown to be concerned with necessary connections between events or circumstances of precisely the sort required for a decent account of singular causation.

## 1. Introduction

There are two very different theories about how the laws of nature relate to the world. One is that they are somehow imposed on things whose identities are independent of the laws. The other is that the laws of nature are immanent in the world, not superimposed upon it. On this view, the laws depend ontologically[1] on the dispositional properties of the things on which they are said to operate, and are therefore not independent of them.

The first is part of the dominant world-view of modern philosophy, viz., Humeanism. By 'Humeanism', I mean a group of related theses: (a) that matter is essentially passive, (b) that the laws of nature are behavioural regularities of some kind, (c) that the laws of nature are contingent, (d) that causal relations hold between logically independent events or states of affairs, (e) that the identities of objects are independent of the laws of nature, (f) that the dispositional properties of things are not intrinsic, but depend on what the laws of nature happen to be, and (g) that modal properties supervene logically on non-modal properties, so that we could not have any difference in modal properties if there were no differences in non-modal properties. I do not say that every Humean holds all of these theses, or even that they all originate with Hume. But they do constitute what most philosophers would consider to be a Humean package.

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[1] For an explanation of my use of the term 'ontological dependence' in this context, see Section 3.2 below.

The Humean package does not derive only from Hume, but has roots in the whole mechanistic philosophical movement which led up to him. Mechanism may no longer be tenable, but Humeanism embraces a number of theses which clearly belong to this tradition. For example, the thesis that the laws of nature are contingent, and operate in a world consisting of things with intrinsic properties which do not depend on what the laws of nature are, makes good sense if one thinks that the only properties that are inherent in bodies are the Lockean primary qualities. For these qualities are all essentially passive, and, except for impenetrability, they are all non-dispositional. If inertia is included along with the primary qualities as a property that is inherent in things, then it too is passive. Some passive dispositional properties might thus be allowed to be inherent or intrinsic. However, even these are arguably dependent on the laws of nature, as the dominant world-view requires. For, if any things had any dispositional properties essentially, and hence necessarily, then they would be bound to behave in ways determined by these properties, rather than as the imposed laws of nature might require. They would, therefore, not be bound by these laws.

Current exponents of the dominant world view are not, of course, committed to the ontological views of any of their predecessors. Nevertheless, they still think of the world as made up of essentially passive things behaving in ways which are determined, or made probable, by their intrinsic non-dispositional properties, by the circumstances in which they exist, and by the laws of nature. The laws of nature, on this view, specify how things of various kinds, distinguished from each other by their intrinsic non-dispositional properties, do, or are likely to, behave in various circumstances.

The second world-view is essentialism. This is the sort of theory I have been defending in a number of places recently.[2] It is not a view which has been widely accepted in modern times. One has to go all the way back to Aristotle to find a truly notable defender of essentialism. Yet, essentialism is precisely the sort of metaphysic that one would expect any modern scientific realist to accept. It is a bottom-up sort of theory, rather than top-down, and it depends on taking a realist, non-reductionist, view of the causal powers, capacities and propensities of the most fundamental things in nature, and assuming them to be ultimately responsible for determining how these things are intrinsically disposed to behave. So, according to scientific essentialism, the causal laws are ontologically dependent on the dispositional properties of things. They are not laws which are imposed on things which are essentially passive, and are thus bound to do as the laws command.

Indeed, a realist would now be hard put to make any sense of the passive world on which the causal laws are supposed to operate. For the world,

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2 See Ellis and Lierse (1994), Ellis (1996), Ellis (1999a, 1999b and 1999c) and Ellis (forthcoming).

according to modern science, seems not to be innately passive, but fundamentally active and reactive. It is certainly not a mechanistic world of things having only the attributes of extension and impenetrability, as Descartes' and Locke's worlds were. Rather, it is a dynamic world consisting of more or less transient objects which are constantly interacting with each other, and whose identities depend on their causal powers, capacities and propensities, i.e., on the dispositional properties which determine their roles in these interactive processes.[3]

In this paper, it will be argued that causal processes are the displays of causal powers, and that the species of laws that we call '*causal laws*' describe the natural kinds of processes to which these displays belong. I will have nothing to say here about other kinds of laws, viz., (a) the *global laws*, which describe the intrinsic natures of the events and processes which are metaphysically possible in our world,[4] (b) the *general structural principles*, such as those of General Relativity, and Pauli's Exclusion Principle, which define the spacetime or causal structure of all worlds of the same natural kind as ours,[5] and (c) *laws of essential nature*, which describe the real essences of the various natural kinds of things, such as fundamental particles, chemical substances, and fields, existing in our world.[6]

From an essentialist's perspective, the causal processes, whose natures are here being investigated, are driven by the intrinsic dispositional properties of the things involved in them. They are not driven by forces which have any

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3 I do not say that the only fundamental properties in nature are dispositional. On the contrary, I would argue that spatial and temporal relations are non-dispositional, and that many properties on which the identities of things might well depend, such as shape, size, and the various structural properties which depend on these relations, are non-dispositional. But nothing is just structure, and the identities of the most fundamental kinds of things in the world always depend in some ways on their causal powers, capacities and propensities. For a discussion of this point, refer to Ellis and Lierse (1994).

4 A conservation law, for example, states that the only events and processes that can occur in our world, or in any world of the same natural kind as ours, are those that are intrinsically conservative in some respect. The theory of such laws is developed in Ellis (forthcoming).

5 I suppose that the global laws and structural principles reflect essential properties of the world itself. They have the kind of necessity that causal laws have, but they do not derive from the essential natures of the things which together make up the world. Rather, they come from the essential nature of the world itself. For the world, as I and my colleagues have argued (Bigelow, Ellis and Lierse, 1992), is not just a haphazard collection of things distributed in space and time, but is itself a member of a natural kind. Whether there is more than one such member we do not know. But the world is fairly clearly a unity of a sort which would be well explained by the hypothesis that it is a member of a natural kind. The global laws and structural principles describe the essential nature of the world, and of all worlds of the same natural kind as ours.

6 Such laws often occur in what are presented as definitions. But they are not ordinary nominal definitions; they are *real definitions*. That is, they specify what is essential to the kinds being defined, rather than conditions for the applicability of the terms used to refer to them. Maxwell's laws of electromagnetism are laws of this kind. Together, they constitute a real definition of the electromagnetic field.

existence apart from the causal processes in which they are involved. When one thing A acts upon another thing B in virtue of some causal power $P_A$ of the kind P, we may say that A exerts a P-force of a certain magnitude and direction on B. But this force is not something which exists apart from the action. It is simply a quantification of the action due to $P_A$ on B, considered without reference to any other actions which may be occurring at that time. The causal laws which describe the generation and action of P-forces are nothing but analytic descriptions of causal powers of the kind P.[7]

The causal processes which are the displays of a given kind of causal power must be essentially similar. For the same kind of power must always have the same law of action, whether that law be deterministic or probabilistic. Therefore, the processes which arise from the exercise of a given kind of causal power must all be processes of the same natural kind. Essentialism therefore leads us to think of the world as containing, not only natural kinds of objects or substances, but also natural kinds of processes. The processes we call 'causal processes' are thus species of natural kinds of processes.

## 2. Scientific Essentialism

Scientific essentialism is a scientific realist metaphysic. According to this theory, the world consists fundamentally of things belonging to natural kinds existing in a world with a certain kind of global structure. Things of these natural kinds are distinguished from each other by their intrinsic properties and structures, and included amongst these intrinsic properties, there are always some which are dispositional, i.e., of the nature of causal powers, capacities or propensities.

As scientific essentialists understand them, dispositional properties are postulated as genuine occurrent properties of things in order *to explain the dispositions they manifest*, i.e., to explain how they will (or will be likely to) behave in various kinds of circumstances. Such explanations are easily parodied. For they often appear to be trivial. The manifest disposition of takers of a given drug to go to sleep following its ingestion is only trivially explained by saying that the drug is a soporific. Nevertheless, this is an explanation, and it is not the only possible one. The drug-taker might believe that the drug is a soporific, when in fact it is only a placebo, and the disposition to sleep might well be caused by this belief, rather than by the nature of the drug that is taken.

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[7] Descriptions of causal powers are likely to employ variables referring to distances and time-intervals—quantities which are clearly not dispositional. A current flowing through a wire, for example, generates a magnetic field around it according to the right hand thumb rule. To describe this causal power, it is necessary to say how this magnetic field would be distributed spatially in relation to the wire, in the absence of any perturbing influences, and how it would vary with the strength of the current. The fact that non-dispositional properties are involved in this description is interesting, however. They are not involved as causal powers, but rather as dimensions of those powers.

The dispositional properties of things are the causal powers, capacities, and so on, which are postulated to explain the dispositions that things naturally have. In the simplest kind of case, a dispositional property is one that is linked essentially and directly to a certain natural kind of causal process, viz., that kind of process which is a display of this property. Of course, a causal process which is superficially like one of a given natural kind might be faked, or be due to some combination of other dispositional properties. So a genuine dispositional property cannot be *defined behaviouristically*. Nevertheless, like natural kinds of objects, natural kinds of processes may be *designated*, and the dispositional properties postulated to explain them may thus be defined theoretically as those properties which would explain them as their displays.

Of course, it may be possible to identify a dispositional property descriptively. For it may be sufficient to secure reference to the kind to specify behaviouristically the kind of process which is typical of it. The identification of natural kinds of processes is not, however, fundamentally different from the identification of natural kinds of substances. Descriptions have a role in fixing reference to a kind, even though the real essence of the kind is something different.

A natural kind of process which is a display of a dispositional property has, however, a certain real definition. And it is one of the primary objects of science to try to discover what the real definitions of the various natural kinds of processes are. In the case of any simple causal process, the real essence will be a dispositional property, and the scientific problem will be to specify precisely what this property is. In general, the real essence of a causal process of a given natural kind will be specifiable counterfactually by the kind (or kinds) of circumstance C in which it *would be* triggered, and the kind (or kinds) of outcome E which *would* (or would with probability $p$) result, *if there were no interfering or distorting influences.* In the simplest kind of case, in which the dispositional property can only be triggered or displayed in one way, the dispositional property may be uniquely characterised by an ordered pair <C,E>, where 'C' denotes a kind of circumstance, and 'E' a kind of event. If $x$ is an object which has this dispositional property, then $x$ may be said to have the power, capacity or propensity to E in circumstances C. However, it is not an *a priori* matter what the real essences of the natural kinds of processes are, and what is being determined is not the meaning of a dispositional term.

Real dispositional properties are thus taken to refer to natural kinds of processes,[8] and like all real properties, they exist independently of our

[8] Many of the most important discoveries in science concern natural kinds of processes and their essential natures. Newton, for example, showed that the apparently different kinds of processes of falling towards the earth and orbiting the sun are essentially the same. Similarly, Lavoisier showed that respiring, rusting and burning are all essentially

systems of classification. I suppose the natural dispositions to be simply the real essences of the natural kinds of processes they describe. That is, I suppose that an object cannot participate in a process of a given natural kind, e.g., to E in circumstances C, unless it has the requisite dispositional property E-ing in these circumstances. In contrast, artificial or socially constructed kinds of processes do not have real essences, and the dispositions defined with reference to such processes are not grounded in corresponding dispositional properties.

The identities of occurrent dispositional properties thus depend on what they intrinsically dispose their bearers to do, i.e., on the causal roles they determine. And, according to scientific essentialism, the world consists fundamentally of things whose kind-identities (See Section 3.4 below) in turn depend on their having just such properties. If this is right, then it follows that the causal laws which describe the natural kinds of processes must all be grounded ultimately in the essential dispositional properties of the natural kinds of things which go to make up the world. And, if that is so, then the causal laws are not contingent,[9] but metaphysically necessary (See Section 3.1 below); and they are not superimposed on the world, but are immanent in it.

The point may be put in more familiar terms by translating it into the language of possible worlds. The causal laws are immanent in the world in this sense: there is no possible world which has different causal laws from ours, but contains all and only the same basic natural kinds of things as our world. It may also be expressed as a supervenience thesis: the causal laws that are instantiated in our world supervene logically on the fundamental natural kinds of things that exist in our world.

To discover what the laws of nature are, the scientific essentialist believes that we must investigate nature empirically to find out what kinds of things exist, and how they are intrinsically disposed to behave. The causal laws of nature are therefore *a posteriori.* To say that they are metaphysically necessary is not, therefore, to imply that they are *a priori.*[10]

Scientific essentialism naturally focuses our attention upon natural kinds and their dispositional properties. Natural kinds, it is argued, are distinguished from other sorts of things in several ways. Specifically, they are objective kinds. That is, they are kinds which exist in nature independently of our classificatory systems. Their existence does not depend on how we think about the world, what language we use, what distinctions we make, or what

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processes of oxidation. Malcolm Forster (1988) talks of discovering a common cause in these and similar cases. But these discoveries are best described as discoveries of sameness of essential nature.

9 If there is any contingency, it concerns the global structure. The same causal laws must hold of the same kinds of things in all worlds in which they exist.

10 This is explained more fully in Section 3.1 below.

classes of things we recognise as existing. Diamonds, for example, would exist as a separate class of entities, whether or not anyone knew about them, or knew how to distinguish them from, say, quartz crystals. Moreover, natural kinds are clearly distinct from each other, i.e., they do not merge one into another, so that an arbitrary distinction would have to be made to separate them. There is, for example, no half-way house between copper and the next element on the periodic table. They are as different as chalk and cheese. The distinctions between natural kinds thus exist objectively. They are there in nature for us to discover, whether or not we recognise them, and they cannot be defined into or out of existence.

As I understand them, natural kinds are not only distinct from each other, but are distinguished by an indefinite number of intrinsic properties or structures which are severally necessary and jointly sufficient for membership. These properties and structures together constitute the *real essence* of the kind, and things which belong to the kind have these properties necessarily, in virtue of being things of the kind they are.

Scientific essentialism thus implies that to accept the traditional Humean view that the dispositional properties of things depend on the laws of nature is to get the relationship of ontological dependence between dispositional properties and laws of nature the wrong way around. For the laws of nature, according to scientific essentialism, are not regularities imposed on a passive and obedient nature, but derive from the intrinsic dispositional properties and constitutions of the things that go to make up the world. In other words, the laws of nature are immanent in things; they are not the principles according to which they are externally regulated.

There is, of course, much work needed to motivate, elaborate and defend scientific essentialism—a task that is well beyond the scope of the present paper. The elaboration and defence of scientific essentialism has been undertaken in a book-length study (Ellis, forthcoming). Here I can only appeal to the reader to suspend judgement on the overall viability of the program, and to focus on its implications for the theory of causation.

## 3. Some Essentialist Concepts

There are several important concepts relevant to the thesis of this paper which may need some explanation:

### *3.1. Metaphysical Necessity*

If what is logically necessary is just what is true in all possible worlds, then metaphysical necessity is a species of logical necessity. For what is metaphysically necessary is what is substantively true in all worlds in which the things or kinds of things referred to exist, and vacuously true in all other worlds. But if logical necessity also implies *a priority*, then metaphysical

necessity is not a species of logical necessity. For what is metaphysically necessary depends on what things, or kinds of things there are, and this is something which can only be discovered empirically. That is, metaphysically necessary propositions are necessary *a posteriori.*

The proposition that water is $H_2O$, for example, is metaphysically necessary. For it is true in every possible world. It is true, for example, in Putnam's possible world in which a stuff XYZ, having the appearance and functional role of water, exists, but in which water does not exist. In this other world, the proposition that water is $H_2O$ is vacuously true. It does not matter what XYZ might be called in this other world; the proposition that it is $H_2O$ is not only false, it is necessarily false. For the proposition that water is $H_2O$ is not true in virtue of the language in which it is expressed. It is true in virtue of the essential nature of the stuff to which the word 'water' refers. If the inhabitants of this other world speak Twin-English, and call XYZ 'water', then the proposition of Twin-English that would be expressed by 'Water is $H_2O$' would be necessarily false. For the stuff they refer to by the name 'water' is not $H_2O$, but XYZ.

Essentialists thus distinguish between metaphysical necessity and analyticity. What is analytic, they say, is what is true in virtue of the meanings of words, or of the conventions of language. They are *de dicto* necessities. Metaphysical necessities, in contrast, do not hold just in virtue of the conventions of language. They hold in virtue of the natural kinds of things that exist, and the properties which determine their memberships of these kinds. Consequently, such necessities are independent of the conventions of language. They are necessities *de re.* To illustrate: suppose I do not know what water is called, but I do happen to know that the stuff in the glass in front of me is $H_2O$. Then what I know, viz., that this stuff is $H_2O$, is metaphysically necessary. But the sentence 'This stuff is $H_2O$' is certainly not analytic.

What is usually thought of as logical necessity is something different again. It is truth in virtue of logical form. According to some, truth in virtue of logical form derives from the conventions of language concerning the use of certain connectives and operators. These philosophers would thus seek to reduce truth in virtue of logical form to a species of analyticity. According to others, truth in virtue of logical form derives from the laws of thought. But, in any case, the ground of logical necessity, properly so-called, is clearly very different from that of metaphysical necessity. Metaphysical necessities are grounded in the natural kinds of things that exist in the world.

Scientific essentialists hold that the causal laws specifically, and the laws of nature more generally, are all metaphysically necessary. Hence, they would identify causal or natural necessity with metaphysical necessity. What is metaphysically necessary in our world, they would say, is what is non-vacuously true in all worlds of the same natural kind as ours which contain

all and only the same basic natural kinds of things. If the same chemical substances exist in any such worlds, they will be intrinsically disposed to interact with each other in precisely the same ways. Hence the thousands of laws describing the various possible chemical interactions must all be metaphysically necessary.

Judgements about what are metaphysically necessary, possible or impossible are much more difficult to make when we are not dealing with the properties of, or interactions between, things belonging to natural kinds. For it is never just a question of what we can imagine cartoon-like to happen. It is always a question of what is really possible, given that the natural kinds of which they are ultimately composed must behave according to their essential natures. So it comes down to the question of what is logically possible, given the contingent circumstances and the metaphysically necessary laws of nature.

### *3.2. Ontological Dependence*

The relation of ontological dependence is closely related to that of logical supervenience,[11] but is not quite the same. To say that a thing of one kind is ontologically dependent on something of another kind is at least to say that it is metaphysically impossible for things of the first kind to exist, unless things of the second kind also exist. For example, to say that a property $P_1$ is ontologically dependent on a property $P_2$ is at least to say that the property $P_1$ does not exist in any possible world in which the property $P_2$ does not also exist. In this respect the relation is like that of logical supervenience. However, logical supervenience is not quite the relation we need for the purposes of ontology. For, as logical supervenience is commonly defined, the subvenient base for the property $P_1$, on which $P_1$ may be supposed to be ontologically dependent, may be much too broad. It may, for example, be the class of all physical properties, or all categorical properties, and so contain many properties which are irrelevant to whether anything has the property $P_1$.

I use the following definitions: (1) A class of properties B is a *relevant subvenient basis*[12] (RS-basis) for a property P if and only if something's having all of the properties in B is a logically sufficient, but not a redundantly sufficient,[13] condition for its having the property P. (2) A property P is *onto-*

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11 As defined in Tooley (1993).

12 I speak of the *relevant subvenient basis* or *RS-basis* of a property rather than its *causal basis* (See Prior, Pargetter and Jackson, 1982.) because it is important to distinguish clearly between the RS-basis of a causal disposition and the causal antecedent of such a disposition.

13 That is, there is no subset of properties in B which is logically sufficient for the object's having the property P.

*logically dependent* on the properties B if and only if the properties B belong to every RS-basis for P.[14]

Given these definitions, it is evidently possible for a property P to have one or more RS-bases. If a property P must always have the same RS-basis B, i.e., if nothing could have the property P without having all of the properties in B, then P may be said to be *ontologically reducible* to B. On the other hand, if it is possible for different occurrences of a property P to have different RS-bases, then P is not ontologically reducible to any of its RS-bases. No such reduction is possible, because the various occurrences of P are not necessarily manifestations of the same basic state of affairs. What unites the various occurrences of P, and gives rise to their common classification, can only be some more or less superficial similarity of appearance, behaviour or function. It cannot be the case that all of the things having this property are essentially the same.

Given these definitions, it is possible that there are real properties which have no RS-bases. All such properties may be said to be *ontologically basic properties.* Plausibly, such ontologically basic properties must exist, although we may not yet know what they are. The most plausible candidates for the role of ontologically basic properties would seem to be those of the fundamental particles. However, it must be doubtful whether these properties (which are generally of the nature of causal powers), could exist if spatio-temporal relations (which are presumably categorical), did not exist. So spatio-temporal relations may reasonably be supposed to be amongst the ontologically basic universals. However, there is no reason to think that the causal powers of the fundamental particles can be ontologically reduced to spatio-temporal relations. So, the ontology I would favour is one which includes *both* causal powers and spatiotemporal relations as basic. Whether there are any non-dispositional, but ontologically basic, properties, as opposed to relations, I do not know. There are structures, certainly, e.g., atomic and molecular structures, which are non-dispositional. But arguably the parts of these structures are distinguishable by their different causal powers, and the structures themselves are ontologically reducible to the spatio-temporal relations between these elements.

The sense in which a law of nature L may be said to be ontologically dependent on one or more dispositional properties D may now be explained: L is a law of nature in every world in which all of the properties D exist, and is not a law of nature in any possible world in which any of the properties D do not exist. That is, the world's having the property of being an L-world is

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[14] Given this definition, it is clear that P is not ontologically dependent on the supposed disjunctive property PvQ, even though P could not be instantiated unless PvQ were also instantiated. For, instantiation of PvQ does not entail instantiation of P. It should also be clear why being red is not ontologically dependent on being not blue. For being not blue is not a sufficient condition for being red.

ontologically reducible to its being D-world. There might indeed be mock L-worlds, in which L appears to hold as a law of nature. But since the L-like behaviour of things in a mock L-world is not ontologically grounded in the dispositions D, then this L-like behaviour is either not metaphysically necessary, or else it instantiates some other law or laws, which, in the contingent circumstances of that world, happen to give rise to the same manifest behaviour patterns.

*3.3. Intrinsicality:*

My concept of intrinsicality derives from causal considerations, rather than a logical ones. In most theories it is assumed that intrinsicality is a *formal property of properties*, and hence that we should be able to distinguish *a priori* between intrinsic and extrinsic properties.[15] But no such theory is satisfactory, and it is not, in any case, what is needed for science. What is needed for science is not an *a priori* distinction, but an *a posteriori* one which reflects the causal structure of the world. Roughly, the distinction required is one between what is due to internal structure and forces alone, and what is due, wholly or partly, to external forces or circumstances. This distinction is a fundamental one in the physical sciences, because abstract theoretical models of physical systems are usually designed specifically to represent the properties and structures of systems in causal isolation from their surroundings.[16]

For most philosophers, shape is paradigmatically intrinsic. For the shape of any object is logically independent of anything external to it. However, the shape of an object is not necessarily the shape it has intrinsically, in the more interesting causal sense of this word. Let A be a stretched rubber band, and G its shape. Now some object might have this shape intrinsically. A steel band, for example, might have this shape independently of the external forces acting upon it. But it is not the case that if *any* object has this shape, then it necessarily has it intrinsically. If the rubber band were causally isolated from its surroundings, it would not have this shape.

Intrinsicality in the causal sense is therefore not a property of properties, as many of those who have tried to explicate a logical concept of intrinsicality have supposed. This is because the very same property (having the stretched rubber band shape) may be an intrinsic property of one thing (e.g., a steel model of a stretched rubber band), and not an intrinsic property of another (viz., the stretched rubber band itself). Causal intrinsicality must

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15 The best known theory of this kind is probably Jaegwon Kim's theory of internal properties (Kim, 1982). Kim's definition of an internal property is equivalent to the following:

G is *intrinsic* $=_{df}$ possibly some object $x$ has G at t, although no contingent object wholly distinct from $x$ at t exists.

16 As Bhaskar (1978) argues so persuasively.

therefore be either a relation between a property and its bearer which is distinct from the normal bearing relation, or else a property of that relation.

I suppose it to be a property of the bearing relation. If an object has the property P intrinsically, then P must be a property which it really has, even if what is manifested or displayed is something different. For I do not want to allow that an object might have the property P intrinsically even though it does not really have this property. If it has the property P intrinsically, then it must really have it. Nevertheless, it might not be what is actually displayed. For in addition to having the property P, the object might be subject to the action of some distorting force F, so that what is actually displayed is not just P but *the resultant of* P *and* F. In the case of the rubber band, we say that the object has a certain shape intrinsically, a shape which is not in the circumstances actually displayed. What is actually displayed results from superimposing a certain distortion on to this underlying intrinsic shape.

Some bodies have intrinsic properties which can change over time. Metals can suffer fatigue, structures can become altered, things can become more elastic, people can acquire beliefs they did not have before, their skills can improve or deteriorate, their concerns for their fellows can diminish, and so on. So, not all bodies hold all of their intrinsic dispositional or structural properties necessarily. Some intrinsic properties are held contingently, and therefore, as we say, accidentally. However, there are some things, viz., those which belong to natural kinds, which hold some or all of their intrinsic properties essentially, i.e., with metaphysical necessity.

*3.4. Kind-essences:*

The sets of intrinsic properties which things belonging to natural kinds hold necessarily (i.e., with metaphysical necessity) are the sets of properties on which their kind-identities depend. That is, they could not lose any of these properties without ceasing to be things of the kinds they are, and nothing could acquire any set of kind-identifying properties without becoming a thing of this kind. These kind-identifying sets of intrinsic properties are the ones called 'the real essences of the natural kinds', although they might, perhaps more correctly, be designated the 'kind-essences' of the individuals which possess them, since the bearers of these properties are undoubtedly the individuals.

Besides having a kind-identity, an individual thing may also have certain properties in virtue of which it is the individual it is. That is, it may have certain properties which it could not lose without ceasing to exist, and which nothing could have acquired, except in the process of becoming that very individual. Often, when people speak of the real essence of a thing, it is the individual essence they have in mind. Saul Kripke (1972), for example, talks of individual essences rather than kind-essences.

Mostly it is assumed that the individual essence of a thing belonging to a natural kind includes its kind-essence. That is, the identity of the individual is supposed to depend on its being just the natural kind of thing it is. If this is right, then an individual of one kind could not possibly be transformed into something of another kind, although it might cease to exist and be replaced by something else. However, I am not at all sure that this is right. Certainly, there are limits to the possibilities of interspecific transformations. A horse could not become a cow. But when an atom loses an electron by β-emission to become an atom one greater in atomic number, it is not at all obvious that the former atom has just ceased to exist, or that a new atom has come into being at precisely the place where the first atom was. Most plausibly, the former atom has just lost a nuclear electron, and thereby changed its nature. For there is a powerful continuity argument to suggest that, as an individual, the former atom still exists, but now as an atom of another kind.

For these reasons, I am reluctant to accept, as Bigelow (1999) urges me to, that the individual essence of a thing belonging to a natural kind includes its kind-essence. Nor do I think that I have to accept this thesis to provide a sound basis for scientific essentialism. For individual essences would seem to have very little to do with kind-essences. The identity of something as an individual seems to depend primarily on its temporal and causal history, and therefore on its extrinsic, not its intrinsic, properties. Therefore, a separate argument would be needed to show that an individual cannot change its kind essence. If, as a matter of fact, individual things cannot ever change from being essentially a thing of one kind to essentially something of another kind, or cannot do so except within very narrow limits, then this is presumably a fact about the kinds of things that exist in our world, rather than a necessary condition for individual identity.

### *3.5. Causal Powers:*

Scientific essentialism depends on the thesis that all things, at all levels of existence down to the ontologically most basic, have causal powers, capacities or propensities.[17] It is important, therefore, to say something about them. First, these properties are quantitative universals.[18] They exist in nature, independently of our knowledge of them, and have real essences which scientists seek to discover. Secondly, the real essences of these properties lie in the sets of quantitative dispositions they underpin.[19] The property of acid-

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17 Whether they also have non-dispositional properties at all such levels is not so clear. My inclination is to think that they do not.

18 For a development of the theory of quantitative universals, see Ellis (forthcoming), Ch. 2.

19 In his reply to my 1999a paper, Armstrong (1999) has objected that such properties are Meinongian. (See also Armstrong's contribution to the forthcoming Shoemaker volume of *Philosophical Studies*.) The objection hinges on the fact that, in most cases, most of the dispositions underpinned by a given dispositional property will never actually be mani-

ity, for example, is a causal power.[20] Essentially, it is the capacity of a substance to act as a proton donor in chemical reactions, but of course this is something we had to discover. Like any other causal power, its identity depends on its causal role. For what makes something an acid is just its being intrinsically disposed to behave in the manner of an acid. An acidic solution, for example, is one which is intrinsically disposed to neutralise solutions containing free $OH^-$ ions by supplying $H^+$ ions to form $H_2O$. Of course, such a disposition could occasionally be thwarted. The addition of a drop of acid to an NaOH solution might trigger off some mechanism which pours a bucket of extra caustic soda into the solution. But such a possibility is irrelevant. If the substance we are dealing with is an acid, then it is *intrinsically* disposed to behave as an acid must, whatever behaviour may *actually* result from all of the causes acting in the circumstances.

The real essence of a causal power is what makes it the causal power it is, and what distinguishes it categorically from any other causal power. Clearly some causal powers will be ontologically dependent on underlying structures, and on the causal powers of the elements of these structures. So, many causal powers will be ontologically dependent on categorical properties, (such as the possession of a given structure may legitimately be supposed to be). But no causal power will be ontologically dependent *only* on categorical properties. Therefore, causal powers are not ontologically *reducible* to categorical properties of any kind. If they are ontologically dependent on any other properties at all, then the set of all such properties must include at least some properties which are themselves causal powers. It is not necessary, however, that causal powers should be ontologically dependent on other properties. For as we chase down the chains of ontological dependence, it is evidently possible that we will run out of structure, and be left with causal powers which are ontologically basic. Presumably, some of the causal powers, capacities and propensities of the fundamental particles are of this kind.

The processes involved in the displays of causal powers all belong to natural kinds. For they are processes which are, and can only be, initiated in circumstances apt for the exercise of these powers, and what is essential to them as processes is precisely that they are the actions of such properties in such circumstances. Every measurement of a causal power or capacity, for

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fested. What then is the relationship between the property and any one of these unmanifested possible manifestations? About all one can say is that it must have a potentially necessary relationship to it—one which would be actualised only if the circumstances which would trigger the dispositional property to act in this way were to occur. My reply to the Meinongian objection is contained in Ellis (1999c).

20 Other such properties are elasticity, electrical conductivity, magnetic permeability, refractive index, specific heat at constant pressure, moment of inertia, latent heat of fusion, specific gravity, and so on. There are hundreds of such properties which are more or less important in science. They are all quantitative, and for each of them there is a causal law describing the natural kind of process that is involved in its display.

example, is a measure of the effect produced by the display of this power or capacity. There is, therefore, a close link between natural kinds of processes, causal powers, and the circumstances of their displays. Specifically, if anything has a given causal power or capacity, then it must be disposed to act in the appropriate kind of way, in the appropriate circumstances. Moreover, if anything has this power essentially, then it is necessarily the case that it will be disposed to act in this kind of way in circumstances of this kind.

Most causal powers are quantitative, and all of them are essentially dispositional. That is, their identities depend on the dispositions to which they give rise. For any given causal power, there is a range of possible displays, normally related by a probability function from the state of the object which possesses it, and the properties of the circumstances in which it can be activated. The range of possible ways in which a given causal power or capacity can act then defines a natural kind of process. It is a process which belongs to a natural kind, because processes of this kind are categorically distinct from processes of any other kind. Moreover, there is no process, however similar in appearance, which is a process of this kind, which is not an action or display of this causal power or capacity.

There is, for example, no possible case of refraction which is not due to the refractivity of some medium. With suitably placed diffraction gratings and mirrors one might produce something which looks just like refraction; the colours might even be dispersed in the proper way. But since, by hypothesis, the dispersal is not produced by the refractivity of any medium, it cannot be a case of refraction. Causal powers, and the natural kinds of processes which are their displays, thus go hand in hand, and are interdefinable.

The possible displays of any given causal power or capacity are all processes which are essentially similar in their structure, and which differ from each other only in ways which lie within the permitted range of variation for the kind of process concerned. The causal powers of an object are thus the real essences of the causal processes which can occur when that object acts causally. The gravitational mass of an object, for example, is the dispositional property it has which determines its causal role in generating gravitational fields, and hence the effects it has on other objects immersed in these fields.[21] The charge on an object is the dispositional property it has

[21] A referee for this Journal has pointed out that if gravitational and inertial mass are distinct dispositional properties, and there is no common categorical basis for them, then it is mysterious why they should always be the same. I agree that the two dispositions are probably linked somehow, but not in the way suggested by the referee. Einstein was aware of the problem, and sought to resolve it rather differently—by conceptual revision. Weight, which is normally taken to measure gravitational mass, was reconstrued by Einstein as being a measure of the resistance of a body to the acceleration required to counter a body's natural gravitational acceleration in curved spacetime. So, he argued, gravitational mass is really no different from inertial mass. I have never been very happy with this explanation, however, because there is still a conceptual difference between the

which determines its causal role in generating electromagnetic fields, and hence the effects it has on other objects which are in or moving through these fields. Therefore, if anything, say a fundamental particle, has a certain mass and a certain charge essentially, then it must generate such fields in any world in which it might exist, and have precisely the same effects on things of just the same kinds.

## 4. An Essentialist Theory of Causal Necessity

To deduce the causal laws we need to know (1) what the causal powers and capacities of things are, and how they must be disposed to behave, given that they have these powers and capacities, (2) what causal powers or capacities things have essentially, i.e., in virtue of their being the kinds of things they are. For this will enable us to deduce how things must be disposed to behave, given that they are things of the kinds they are. The laws of interaction are similarly derivable. The causal laws concerning two natural kinds of things A and B are descriptions of the ways in which things of the kinds A and B must be intrinsically disposed to interact, in virtue of their being things of the kinds they are. Of course, things may not interact as they are intrinsically disposed to interact. For other forces may come into play. But then the laws of nature we call 'causal laws' allow for this. *The causal laws are not contingent universal generalisations about how things actually behave, but necessary truths about how they are intrinsically disposed to behave.*

Bigelow (1999) objects to this account on the ground that it does not yield metaphysical necessity for the causal laws which can be thus derived. For metaphysical necessity, he argues, we require that the laws be derivable from the natures of the individuals involved, i.e., from their *individual essences*. If the laws of nature do not derive from the individual essences of things, he says, then they cannot be necessary *de re*. At best, they can only be necessary *de dicto*, if indeed they are necessary at all. But Bigelow is wrong about this, as I argued in Ellis (1999b). The laws of nature that I call causal laws are all necessary *de re*.

The laws in question are straightforward descriptions of *the essential properties of the intrinsic dispositional properties* which fundamental things must have in virtue of being things of the kinds they are. That is, they are concerned with the essential properties of essential properties. Let $K_1$ and $K_2$ be natural kinds, '$\Rightarrow$' be the connective 'if...then...', '$C_i$' the predicate 'are in the specific circumstances $C_i$ within a certain range of possible circumstances C', and '$IE_i$' the predicate 'are intrinsically disposed to interact in the manner

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power of a body to curve spacetime and it capacity to resist acceleration. I think the problem is still unresolved, but I do not think it helps to postulate an unknown, but common, categorical basis for the two dispositional properties.

$E_i$ within the range of possibilities E'. *Then the general form of a causal law involving two natural kinds of things* $K_1$ *and* $K_2$ *is*:

**L1**. For all x,y and i, necessarily $[x \in K_1 \ \& \ y \in K_2 \Rightarrow (C_i x,y \Rightarrow IE_i x,y)]$

For example, let $K_1$ be the kind which consists of samples of pure hydrogen, $K_2$ the kind which consists of samples of pure oxygen, and i an index of circumstances in which such pure samples of hydrogen and oxygen are disposed to interact chemically. Then an instance of this causal law would be something like:

> For all x and y, it is necessarily true that if x is oxygen and y is hydrogen, then, if a match is struck in a mixture of x and y, then x and y are intrinsically disposed to combine chemically to form water.[22]

Note that the necessity operator which occurs in a law such as this, which spells out the essential properties of the intrinsic dispositional properties of the kind-essences of things, occurs within the scopes of the universal quantifiers, that is, in a *de re* position. If, as Bigelow insists, individual essences include kind-essences, then the causal law is certainly necessary *de re*. On Bigelow's thesis what we have is:

**L2**. For all x,y and i, $[x \in K_1 \ \& \ y \in K_2 \Rightarrow$ necessarily $(C_i x,y \Rightarrow IE_i x,y)]$

Consequently, if we knew that $a \in K_1$ & $b \in K_2$ we could instantiate to a and b and detach the consequent to obtain 'necessarily $(C_i a,b \Rightarrow IE_i a,b)$'. However, such a strong essentialist claim entails that individuals which belong to natural kinds cannot, in any circumstances, change their natures. This is the thesis which Bigelow urges me strongly to accept. However, for the reasons given, I am not sure that I have to, or that I want to. I remain to be convinced that I must.

The weaker thesis, represented by **L1**, has one clear advantage over **L2**. If **L1** is accepted, then it will be accepted on the basis that causal laws derive not from *the essential properties of individuals*, but from *the essential properties of the intrinsic properties* which individuals belonging to natural kinds must have, in virtue of being members of these kinds. The beauty of this is that it allows us to generalise the account of natural necessity, and to explain

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22 Note that, contrary to Hume's principle, this causal law implies the existence of necessary connections between events. Let $e_1$ be the event of striking a match in a mixture of oxygen and hydrogen, and $e_2$ the event of these gases combining chemically to form water. Then, necessarily $e_2$ will occur if $e_1$ occurs, unless, say, an atomic explosion intervenes to change the circumstances before any chemical combination can take place.

the necessity of those laws of nature which can be stated without reference to natural kinds of objects.

In our (1994), Caroline Lierse and I argued for an ontology which includes natural kinds of properties as well as natural kinds of objects. *Gravitational mass*, for example, is a generic kind of intrinsic causal power. The infimic species of this generic kind are the specific gravitational masses which individuals may possess. Let $M_1$ and $M_2$ be the kinds consisting of individual objects of masses $m_1$ and $m_2$ respectively, and r(x,y) be the proposition that x and y are separated by a distance r. Then, analogous to **L1**, we have:

**M1**. For all x,y and r, necessarily $[x \in M_1 \ \& \ y \in M_2 \Rightarrow (r(x,y) \Rightarrow IE_r(x,y)]$

where $IE_r(x,y)$ is the statement that x and y are intrinsically disposed to accelerate towards each other with accelerations proportional to $m_2$ and $m_1$ respectively, and inversely proportional to $r^2$. However, the law analogous to **L2**, viz.:

**M2**. For all x,y and r, $[x \in M_1 \ \& \ y \in M_2 \Rightarrow$ necessarily $(r(x,y) \Rightarrow IE_r(x,y)]$

is fairly evidently untenable, unless x and y happen to belong to natural kinds. For **M2** requires that the members of $M_1$ and $M_2$ have their specific masses essentially. They may do so, e.g., if they are fundamental particles; but fairly clearly they need not always do so.

Whichever version of the essentialist theory of causal necessity you may accept, it is clear that you must consider the causal powers of things to be primary, and the causal laws involving them to be dependent on them. For the laws are embedded in the powers. Precisely, what makes a power the power it is is what it disposes things which possess it to do. For it acts in a certain way on whatever is sensitive to it, and its manner of acting, when not impeded, or overwhelmed, is just what defines it. It is true that a causal power, such as gravitational mass, cannot be defined, except with reference to how it disposes things to behave in its vicinity. Hence, gravitational mass could not exist in a world in which vicinities did not exist, i.e., in a world which was not extended in space and time. Gravitational mass is therefore ontologically dependent on there being such a world. But it does not follow that gravitational mass is ontologically *reducible* anything more fundamental. In particular, it does not follow that gravitational mass is ontologically reducible to categorical properties plus laws of nature. No. The causal laws are embedded in the properties.

## 5. Causal Processes

It is one of the aims of physical science to discover and to describe the causal powers and capacities of things, and hence the necessary connections between

kinds of events or circumstances implied by their existence. These powers and capacities are the truthmakers for those laws of nature which are generally known as causal laws. Causal powers and capacities therefore have a very important role in determining what happens in the world. They are its driving and regulating forces.

However, the causal processes we are directly aware of are mostly very complex. They are not straightforwardly instances of causal laws. No doubt all instances of causation are reducible to elementary causal processes involving elementary events and processes, and all elementary causal processes must be instances of causal laws. But the standard exemplars of causal processes are not elementary. Typically, they involve a great many microlevel processes, occurring in a kind of avalanche. For example, when one billiard ball strikes another, a very large number of causal interactions between the parts of the balls, the surface of the table, and the air in which the process occurs, is set in train. And it is this avalanche of causal processes which results in the apparently simple macroscopic causal process that is actually observed. But this macroscopic process is not really simple, and it is not an instance of any causal law. It is far too complex to be a display of a simple causal power.

This is not to say that a complex causal process, like a collision between billiard balls, cannot display nomic connections. For, as in this case, a macroprocess may be a sum of many microprocesses each of which is intrinsically and necessarily conservative of various quantities (linear momentum, angular momentum, energy). In such a case, the macro-level process must itself be intrinsically conservative of these quantities. Moreover, the transfers of energy, momentum, etc. which occur when billiard balls collide must occur, as they always do, with nomic, or metaphysical, necessity. For the complex sequence of events which constitutes the cause necessitates the complex sequence which constitutes the effect.

However, not all of the exemplars of causation are like the billiard ball example. In the billiard ball case, the causation is direct, and involves the cumulative effect of many different causal actions. But sometimes the so-called effect is not directly due to the action of any causal powers, but to their permission or interruption. When I pull the blinds to darken the room, I achieve the effect by interrupting the process which causes it to be illuminated. My darkening the room is therefore not a display, cumulative or otherwise, of any causal power of mine other than my power to pull down the blinds. Moreover, what I do in pulling the blinds down is not importantly different from what I would do if I were to raise them again. By raising the blinds, I would lighten the room, but I would achieve this effect, not by exerting a causal power on the room, but rather by removing an obstacle to the action of one. In both cases, my role is indirect. It is that of a moderator or regulator, changing the circumstances in which another causal process is

operating. Thus, in raising or lowering the blinds, I act to moderate another causal process, one which has its origin in the sun.

It appears, therefore, that there is a distinction to be drawn between direct and indirect causation. In the case of direct causation the effect is brought about by a transfer of energy from the object which has the causal power to the object which is affected by it. Thus, light emanating from the sun is the direct cause of illumination in my room. My pulling the blinds is the direct cause of the blinds being lowered. But the blinds being lowered is not the direct cause of the reduced level of illumination in my room.

Let us, therefore, distinguish between directly and indirectly acting causes. Phenomenologically, there may not be much difference between the two kinds of causation. But ontologically there is a considerable difference. There may indeed be regularities of indirect causation which are suggestive of causal power. But every such case must be illusory. For indirect causation is always the result of modifying the circumstances in which a causal power is acting. It is never the direct exercise of a causal power.

The theory that causal processes are fundamentally just the displays of the intrinsic causal powers and capacities of things, does not, therefore, apply straightforwardly to all of the processes we consider to be causal. Our judgements about causal relationships are not based on their underlying causal explanations. Rather, they depend on perceived regularities amongst events, knowledge of other causal relations, and on the kinds of powers that things are generally believed to have—more or less as Hume believed. No doubt most of the regularities we consider to be causal can be explained in terms of the actions of causal powers. But the underlying causal structure of these processes has to await scientific investigation; it cannot be read off just from the surface phenomena.

## 6. Singular Causation

According to Armstrong (1997), singular causation is token causation. It is the causation which is manifested in a particular causal sequence of events or states of affairs, such as that which is produced by the triggering, and consequent display, of a given causal power. Humeans have a problem with singular causation, because any sequence of events which conforms to the pattern of a given causal sequence must be an instance of that pattern. And, if there is nothing more to such causation than the regularity which is characteristic of the pattern, then there is nothing to distinguish a perfect fake from a genuine instance of causation. The fake might be distinguished from the genuine instance counterfactually. But Humeans notoriously have great difficulty in giving a satisfactory account of the counterfactuals required which does not presuppose the very distinction they wish to make.

Armstrong, who thinks that the dispositional properties of things depend on the laws of nature which apply to them, and who construes laws of nature

as contingent relations of natural necessitation between universals, should have less of a problem than a Humean, because fake or counterfeit instances of universals are not instances of them. But Armstrong makes rather heavy weather of it, because he is committed to a basic ontology of instantaneous, and presumably point-like states of affairs, each of which is logically independent of every other. If an ordered pair of them, say <A, B>, should instantiate a relation of causation then this cannot be inconsistent with the conversely ordered pair, <B, A>, also instantiating this relationship. Moreover, if the pairs, <A, B> and <B, C>, should both instantiate the causal relation, this cannot entail that <A, C> also instantiates it. To deal with this problem, Armstrong introduces an immediate and underlying causal relation, causation*, which is not necessarily either asymmetrical or transitive. Singular causal relations, he says, are the ancestrals of causation* relations. So singular causal relations, as defined, must be transitive. They may, in fact, also be asymmetrical. But if so, then this is a fact about the world, not one which is grounded in the underlying causation* relations.

Armstrong gets into these difficulties, I believe, because his ontology is still basically Humean. It is an ontology of independent states of affairs, which like events in a Humean ontology, are loose and separate. He thus begins from behind the eight-ball when it comes to explaining the lawlike structure of the world. For, like Hume, he seems to be left with nothing but a regularity theory to explain the lawlike structure of the world. But Armstrong has a way of explaining regularities which is compatible with his austere states of affairs ontology. Specifically, he postulates that the laws of nature are not just accidental regularities, but regularities which depend ontologically on relations between universals. The regularities could exist by chance without such a basis, says Armstrong, but given that these relations exist, and that the objects involved possess the appropriate properties (i.e., have tropes of the appropriate universals), the regularities must also exist.

Like all neo-Humean ontologies, Armstrong's ontology of states of affairs has no natural place within it for causal powers. For causal powers are supposed to be grounded in the intrinsic, non-dispositional (i.e., categorical) properties of things and contingent laws of nature. The causal powers of things are therefore supposed to depend on what the laws of nature happen to be in our world, i.e., on what relationships happen to exist in our world between universals. According to the doctrines of Seventeenth and Eighteenth Century mechanism, things in themselves are powerless, and passive. So causal powers were a problem. But the same is true of Armstrong's states of affairs. For they, like motion picture stills, are not necessarily connected with either their predecessors, or their successors.

Indeed, I have some difficulty in seeing how Armstrong could even distinguish between states of motion. For the state of affairs which exists at the place $s$ at the time $t$ when a body is moving with velocity $v$ in a given frame

of reference would seem to be indistinguishable from that which would exist if the same body were at rest at the same place and time. It cannot have anything to do with what were or will be the preceding or succeeding states. It has to be some difference which is intrinsic to the states of affairs, considered as instantaneous. But Armstrong cannot say that the difference is one of dispositional properties, such as inertia or instantaneous velocity must be, because he does not believe in such properties.

Consequently, Armstrong's ontology lacks dynamism. There isn't any obvious mechanism for generating change. If states of affairs succeed states of affairs according to laws, then these laws must be extrinsic to the events they govern. They cannot be the natural expressions of the causal powers of the objects involved.

It seems to me that a decent ontology must incorporate the required dynamism into the natures of things. And this is where the dynamic ontology I would propose comes into its own. For given such an ontology, and things which have causal powers, capacities or propensities essentially, then everything of a given kind must, by its nature, be intrinsically disposed to behave as these properties determine. The theory of immanent causation is thus easily able to account for singular causation. Singular causes are just the singular displays of the causal powers, capacities or propensities of things.

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