

ESSAY FOR THE APOSTLES ON 'ANALOGIES IN NATURE'

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From Campbell and Garnett, *Life of Maxwell*⁽¹⁾

ARE THERE REAL ANALOGIES IN NATURE?⁽²⁾

In the ancient and religious foundation of Peterhouse there is observed this rule, that whoso makes a pun shall be counted the author of it, but that whoso pretends to find it out shall be counted the publisher of it, and that both shall be fined. Now, as in a pun two truths lie hid under one expression, so in an analogy one truth is discovered under two expressions. Every question concerning analogies is therefore the reciprocal of a question concerning puns, and the solutions can be transposed by reciprocation. But since we are still in doubt as to the legitimacy of reasoning by analogy, and as reasoning even by paradox has been pronounced less heinous than reasoning by puns, we must adopt the direct method with respect to analogy, and then, if necessary, deduce by reciprocation the theory of puns.

That analogies appear to exist is plain in the face of things, for all parables, fables, similes, metaphors, tropes, and figures of speech are analogies, natural or revealed, artificial or concealed. The question is entirely of their reality. Now, no question exists as to the possibility of an analogy without a mind to recognise it – that is rank nonsense. You might as well talk of a demonstration or refutation existing unconditionally. Neither is there any question as to the occurrence of analogies to our minds. They are as plenty as reasons, not to say blackberries. For, not to mention all the things in external nature which men have seen as the projections of things in their own minds, the whole framework

(1) *Life of Maxwell*: 235–44; dated by Campbell.

(2) There has been much discussion of Maxwell's ideas on physical analogy: George E. Davie, *The Democratic Intellect. Scotland and her Universities in the Nineteenth Century* (Edinburgh, 1964): 138–45, 192–7; Richard Olson, *Scottish Philosophy and British Physics 1750–1880. A Study in the Foundations of the Victorian Scientific Style* (Princeton, 1975): 287–321; D. B. Wilson, 'The educational matrix: physics education at early-Victorian Cambridge, Edinburgh and Glasgow Universities', in P. M. Harman ed., *Wranglers and Physicists. Studies on Cambridge Physics in the Nineteenth Century* (Manchester, 1985): 12–48 esp. 33–44; P. M. Harman, 'Edinburgh philosophy and Cambridge physics: the natural philosophy of James Clerk Maxwell', in *Wranglers and Physicists*: 202–24; Joseph Turner, 'Maxwell on the method of physical analogy', *British Journal for Philosophy of Science*, 6 (1955): 226–38; Robert H. Kargon, 'Model and analogy in Victorian science: Maxwell and the French physicists', *Journal of the History of Ideas*, 30 (1969): 423–36.

of science, up to the very pinnacle of philosophy, seems sometimes a dissected model of nature, and sometimes a natural growth on the inner surface of the mind. Now, if in examining the admitted truths in science and philosophy, we find certain general principles appearing throughout a vast range of subjects, and sometimes re-appearing in some quite distinct part of human knowledge; and if, on turning to the constitution of the intellect itself, we think we can discern there the reason of this uniformity, in the form of a fundamental law of the right action of the intellect, are we to conclude that these various departments of nature in which analogous laws exist, have a real interdependence; or that their relation is only apparent and owing to the necessary conditions of human thought?

There is nothing more essential to the right understanding of things than a perception of the relations of *number*. Now the very first notion of number implies a previous act of intelligence. Before we can count any number of things, we must pick them out of the universe, and give each of them a fictitious unity by definition. Until we have done this, the universe of sense is neither one nor many, but indefinite. But yet, do what we will, Nature seems to have a certain horror of partition. Perhaps the most natural thing to count 'one' for is a man or human being, but yet it is very difficult to do so. Some count by heads, others by souls, others by noses; still there is a tendency either to run together into masses or to split up into limbs. The dimmed outlines of phenomenal things all merge into another unless we put on the focussing glass of theory and screw it up sometimes to one pitch of definition, and sometimes to another, so as to see down into different depths through the great millstone of the world.

As for space and time, any man will tell you that 'it is now known and ascertained that they are merely modifications of our own minds'.⁽³⁾ And yet if we conceive of the mind as absolutely indivisible and capable of only one state at a time, we must admit that these states may be arranged in chronological order, and that this is the only real order of these states. For we have no reason to believe, on the ground of a given succession of simple sensations, that differences in position, as well as in order of occurrence, exist among the causes of these sensations. But yet we are convinced of the co-existence of different objects at the same time, and of the identity of the same object at different times. Now if we admit that we can think of difference independent of sequence, and of sequence without difference, we have admitted enough on which to found the possibility of the ideas of space and time.

But if we come to look more closely into these ideas, as developed in human

(3) Compare Hamilton's remarks on 'Kant's doctrine of space and time'; see William Hamilton, *Lectures on Metaphysics and Logic*, ed. H. L. Mansel and J. Veitch, 4 vols. (Edinburgh, 1859-60), 1: 402-4, and see Number 16.

beings, we find that *their* space has triple extension, but is the same in all directions, without behind or before, whereas time extends only back and forward, and always goes forward.

To inquire why these peculiarities of these fundamental ideas⁽⁴⁾ are so would require a most painful if not impossible act of self-excenteration; but to determine whether there is anything in Nature corresponding to them, or whether they are mere projections of our mental machinery on the surface of external things, is absolutely necessary to appease the cravings of intelligence. Now it appears to me that when we say that space has three dimensions, we not only express the impossibility of conceiving a fourth dimension, co-ordinate with the three known ones, but assert the objective truth that points may differ in position by the independent variation of three variables. Here, therefore, we have a *real* analogy between the constitution of the intellect and that of the external world.⁽⁵⁾

With respect to time, it is sometimes assumed that the consecution of ideas is a fact precisely the same kind as the sequence of events in time. But it does not appear that there is any closer connection between these than between mental difference, and difference of position. No doubt it is possible to assign the accurate date of every act of thought, but I doubt whether a chronological table drawn up in this way would coincide with the sequence of ideas of which we are conscious. There is an analogy, but I think not an identity, between these two orders of thoughts and things. Again, if we know what is at any assigned point of space at any assigned instant of time, we may be said to know all the events in Nature. We cannot conceive any other thing which it would be necessary to know; and, in fact, if any other necessary element does exist, it never enters into any phenomenon so as to make it differ from what it would be on the supposition of space and time being the only necessary elements.

We cannot, however, think any set of thoughts without conceiving of them as depending on reasons. These reasons, when spoken of with relation to objects, get the name of *causes*, which are reasons, analogically referred to objects instead of thoughts. When the objects are mechanical, or are considered in a mechanical point of view, the causes are still more strictly defined, and are called *forces*.⁽⁶⁾

(4) The term is Whewell's; see William Whewell, *Philosophy of the Inductive Sciences, founded upon their History*, 2 vols. (London, 1847), 1: 66. Compare Numbers 68 and 105.

(5) Compare Whewell on the 'Fundamental Antithesis of Philosophy' between 'Ideas and Senses, Thoughts and Things, Theory and Fact'; Whewell, *Philosophy of the Inductive Sciences*, 2: 647-68, esp. 650.

(6) Compare Whewell's view that the idea of cause construed as force is the 'fundamental idea' of mechanics; see Whewell, *Philosophy of the Inductive Sciences*, 2: 177-254, 473-94; and also Whewell, *An Elementary Treatise on Mechanics* (Cambridge, 1848): 1.

Now if we are acquainted not only with the events, but also with the forces, in Nature, we acquire the power of predicting events not previously known.

This conception of cause, we are informed, has been ascertained to be a notion of invariable sequence. No doubt invariable sequence, if observed, would suggest the notion of cause, just as the end of a poker painted red suggests the notion of heat, but although a cause without its invariable effect is absurd, a cause by its apparent frustration only suggests the notion of an equal and opposite cause.

Now the analogy between reasons, causes, forces, principles, and moral rules, is glaring, but dazzling.

A reason or argument is a conductor by which the mind is led from a proposition to a necessary consequence of that proposition. In pure logic reasons must all tend in the same direction. There can be no conflict of reasons. We may lose sight of them or abandon them, but cannot pit them against one another. If our faculties were indefinitely intensified, so that we could see all the consequences of any admission, then all reasons would resolve themselves into one reason, and all demonstrative truth would be one proposition. There would be no room for plurality of reasons, still less for conflict. But when we come to causes of phenomena and not reasons of truths, the conflict of causes, or rather the mutual annihilation of effects, is manifest. Not but what there is a tendency in the human mind to lump up all causes, and give them an aggregate name, or to trace chains of causes up to their knots and asymptotes. Still we see, or seem to see, a plurality of causes at work, and there are some who are content with plurality.

Those who are thus content with plurality delight in the use of the word force as applied to cause. Cause is a metaphysical word implying something unchangeable and always producing its effect. Force on the other hand is a scientific word, signifying something which always meets with opposition, and often with successful opposition, but yet never fails to do what it can in its own favour. Such are the physical forces with which science deals, and their maxim is that might is right, and they call themselves laws of nature. But there are other laws of nature which determine the form and action of organic structure. These are founded on the forces of nature, but they seem to do no work except that of direction. Ought they to be called forces? A force does work in proportion to its strength. These *direct* forces to work after a model. They are *moulds*, not forces. Now since we have here a standard from which deviation may take place, we have, besides the notion of *strength*, which belongs to force, that of *health*, which belongs to organic law. Organic beings are not conscious of organic laws, and it is not the conscious being that takes part in them, but another set of laws now appear in very close connexion with the conscious being. I mean the laws of thought. These may be interfered with by organic

laws, or by physical disturbances, and no doubt every such interference is regulated by the laws of the brain and of the connexion between that medulla and the process of thought. But the thing to be observed is, that the laws which regulate the *right* process of the intellect are identical with the most abstract of all laws, those which are found among the relations of necessary truths, and that though these are mixed up with, and modified by, the most complex systems of phenomena in physiology and physics, they must be recognised as supreme among the other laws of thought. And this supremacy does not consist in superior strength, as in physical laws, nor yet, I think, in reproducing a type as in organic laws, but in being right and true; even when other causes have been for a season masters of the brain.

When we consider voluntary actions in general, we think we see causes acting like forces on the willing being. Some of our motions arise from physical necessity, some from irritability or organic excitement, some are performed by our machinery without our knowledge, and some evidently are due to us and our volitions. Of these, again, some are merely a repetition of a customary act, some are due to the attractions of pleasure or the pressure of constrained activity, and a few show some indications of being the results of distinct acts of the will. Here again we have a continuation of the analogy of Cause. Some had supposed that in will they had found the only true cause, and that all physical causes are only apparent. I need not say that this doctrine is exploded.⁽⁷⁾

What we have to observe is, that new elements enter into the nature of these higher causes, for mere abstract reasons are simply absolute; forces are related by their strength; organic laws act towards resemblances to types; animal emotions tend to that which promotes the enjoyment of life; and will is in great measure actually subject to all these, although certain other laws of *right*, which are abstract and demonstrable, like those of reason, are *supreme* among the laws of will.

Now the question of the reality of analogies in nature derives most of its interest from its application to the opinion, that all the phenomena of nature, being varieties of motion, can only differ in complexity, and therefore the only way of studying nature, is to master the fundamental laws of motion first, and then examine what kinds of complication of these laws must be studied in order to obtain true views of the universe. If this theory be true, we must look for indications of these fundamental laws throughout the whole range of science, and not least among those remarkable products of organic life, the results of cerebration (commonly called 'thinking'). In this case, of course, the resemblances between the laws of different classes of phenomena should hardly be called analogies, as they are only transformed identities.

(7) Compare Hamilton's account of causality in his *Lectures on Metaphysics*, 2: 376-413.

If, on the other hand, we start from the study of the laws of thought (the abstract, logical laws, not the *physiological*), then these apparent analogies become merely repetitions by reflexion of certain necessary modes of action to which our minds are subject. I do not see how, upon either hypothesis, we can account for the existence of one set of laws of which the supremacy is necessary, but to the operation contingent. But we find another set of laws of the same kind, and sometimes coinciding with physical laws, the operation of which is inflexible when once in action, but depends in its beginnings on some act of volition. The theory of the consequences of actions is greatly perplexed by the fact that each act sets in motion many trains of machinery, which react on other agents and come into regions of physical and metaphysical chaos from which it is difficult to disentangle them. But if we could place the telescope of theory in proper adjustment, to see not the physical events which form the subordinate foci of the disturbance propagated through the universe, but the moral foci where the true image of the original act is reproduced, then we shall recognise the fact, that when we clearly see any moral act, then there appears a moral necessity for the trains of consequences of that act, which are spreading through the world to be concentrated on some focus, so as to give a true and complete image of the act in its moral point of view. All that bystanders see, is the physical act, and some of its immediate physical consequences, but as a partial pencil of light, even when not adapted for distinct vision, may enable us to see an *object*, and not merely light, so the partial view we have of any act, though far from perfect, may enable us to see it morally as an act, and not merely physically as an event.

If we think we see in the diverging trains of physical consequences not only a capability of forming a true image of the act, but also of reacting upon the agent, either directly or after a long circuit, then perhaps we have caught the idea of *necessary* retribution, as the legitimate consequence of all moral action.

But as this idea of the *necessary* reaction of the consequences of action is derived only from a few instances, in which we have guessed at such a law among the necessary laws of the universe; and we have a much more distinct idea of *justice*, derived from these laws which we necessarily recognise as supreme, we connect the idea of retribution much more with that of *justice* than with that of *cause and effect*. We therefore regard retribution as the result of *interference* with the mechanical order of things, and intended to vindicate the supremacy of the right order of things, but still we suspect that the two orders of things will eventually dissolve into one.

I have been somewhat diffuse and confused on the subject of moral law, in order to show to what length analogy will carry the speculations of men. Whenever they see a relation between two things they know well, and think they see there must be a similar relation between things less known, they reason

from the one to the other. This supposes that although pairs of things may differ widely from each other, the *relation* in the one pair may be the same as that in the other. Now, as in a scientific point of view the *relation* is the most important thing to know, a knowledge of the one thing leads us a long way towards a knowledge of the other. If all that we know is *relation*, and if all the relations of one pair of things correspond to those of another pair, it will be difficult to distinguish the one pair from the other, although not presenting a single point of resemblance, unless we have some difference of relation to something else, whereby to distinguish them.⁽⁸⁾ Such mistakes can hardly occur except in mathematical and physical analogies, but if we are going to study the constitution of the individual mental man, and draw all our arguments from the laws of society on the one hand, or those of the nervous tissue on the other, we may chance to convert useful helps into Wills-of-the-wisp.⁽⁹⁾ Perhaps the 'book,' as it has been called, of nature is regularly paged; if so, no doubt the introductory parts will explain those that follow, and the methods taught in the first chapters will be taken for granted and used as illustrations in the more advanced parts of the course; but if it is not a 'book' at all, but a *magazine*, nothing is more foolish to suppose that one part can throw light on another.

Perhaps the next most remarkable analogy is between the principle, law, or plan according to which all things are made suitably to what they have to do, and the intention which a man has of making machines which will work. The doctrine of final causes, although productive of barrenness in its exclusive form, has certainly been a great help to enquirers into nature; and if we only maintain the existence of the analogy, and allow observation to determine its form, we cannot be led far from the truth.

There is another analogy which seems to be supplanting the other on its own ground, which lies between the principle, law, or plan according to which the forms of things are made to have a certain community of type, and that which induces human artists to make a set of different things according to varieties of the same model. Here apparently the final cause is analogy or homogeneity, to the exclusion of usefulness.

(8) Compare Colin MacLaurin's discussion of mathematics: 'the mathematical sciences treat of the relations of quantities to each other... [hence] we enquire into the relations of things rather than their inward essences. Because we may have a clear conception of that which is the foundation of a relation, without having a perfect or adequate idea of the thing it is attributed to, our ideas of relation are often clearer and more distinct than those of the things to which they belong, and to this fact we may ascribe, in some measure, the peculiar evidence of the mathematics'; MacLaurin, *A Treatise of Fluxions*, 2 vols. (Edinburgh, 1742), 1: 51-2.

(9) Compare Maxwell's discussion of moral philosophy in May 1855 in his Apostles essay 'Is Ethical Truth obtainable from an Individual Point of View', prompted by Adam Smith's *Theory of Moral Sentiments* (1759); see Number 62.

And last of all we have the secondary forms of crystals bursting in upon us, and sparkling in the rigidity of mathematical necessity and telling us, neither of harmony of design, usefulness or moral significance, – nothing but spherical trigonometry and Napier's analogies.⁽¹⁰⁾ It is because we have blindly excluded the lessons of these angular bodies from the domain of human knowledge that we are still in doubt about the great doctrine that the only laws of matter are those which our minds must fabricate, and the only laws of mind are fabricated for it by matter.⁽¹¹⁾

(10) See W. H. Miller, *A Treatise on Crystallography* (Cambridge, 1839): 4. Drawing normals from the faces of crystals to the surface of a sphere, the 'sphere of projection' is divided into a network of spherical triangles; '[crystallographic] calculations will be performed by spherical trigonometry', using the Napier analogies for right-angled spherical triangles. See John Napier, *Mirifici Logarithmorum Canonis descriptio* (Edinburgh, 1614): 30–9.

(11) Compare Whewell on the 'fundamental antithesis of philosophy' and the 'fundamental idea of symmetry of crystals'; *Philosophy of the Inductive Sciences*, 1: 16–51, 2: 440–52, 647–68.