God's Order, Man's Order and the Order of Nature

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I The Quiet Revolution

This paper describes a quiet but dramatic revolution in how science is to be understood that is now going on. In this revolution, long-standing ideas of science and nature as completely ordered under the rule of natural law are called into question by scientists, historians, philosophers and sociologists, each grappling with how science works in practice. As a result there has been a fundamental re-examination of how natural order can and should be understood. These new perspectives on nature have exciting, challenging implications for both science and theology, which I hope to give a sense of here.

Since the Scientific Revolution, natural philosophy and Christian natural theology have united to place man in a well-ordered universe, and with powerful argument. Appearances notwithstanding – so the argument goes – the empirical and conceptual successes of modern science testify that we live in a world in which every natural event is the outcome of universal and immutable natural law. This image even survived quantum indeterminacy and chaos: the universe is still universally law-governed though some of its most basic laws are probabilistic and many of its occurrences may be virtually impossible to predict.

In the last decade this 400-year old image has been powerfully challenged, unsurprisingly perhaps in the social sciences, but importantly in biology and even in physics. The challenge appears through an unheralded revolution in the philosophy and history of science where increasingly the traditional view of an ordered science is put into question. This breakdown of order is not along any one fissure nor provoked by any one great discovery like the quantum of action, nor does it emerge from just one science. Rather, it appears in many distinct, highly detailed studies of scientific practice. Though generally unrelated to one another, these diverse studies have in common a radical split from the standard view. They propose alternatives to universal laws as the central explanatory and predictive mechanisms of nature. This questioning of the order of science has come from analyses of successful scientific practice across the disciplines, from fundamental physics through biology to political economy. In philosophy of science it is no longer assumed without question that the order of nature is complete and that its laws are universal and exceptionless. What then does this tell us about God's plan for nature and his plans for us and indeed about God himself?

The tradition of Natural Religion, especially, looks to the world to teach us about the Nature of its Creator, and Natural Religion often has special appeal to scientists because of its emphasis on the empirical basis for religious belief. The intimate connection supposed there between God's Nature and the nature of the world He created implies that this revolution in thought about the order of nature may have profound theological implications. This paper aims in the first place to provide a sense of these new images of nature and in the second to sketch out some deep and very serious new questions they raise about God's role in nature and the role He assigns to mankind for the order that is to emerge in it.

A familiar issue related to my topic is emergentism. Though my concerns here dovetail with this theme they are orthogonal to it. Emergentism has to do with the possible failure of *vertical reductionism*: the idea that the more 'basic' levels of reality do not determine or fix what happens at 'higher' levels; that new phenomena, new characteristics, even new laws of nature emerge at larger dimensions, more mass, higher velocities or increased complexity. Philosophical support for emergentism can be found in wide-ranging work in philosophy of science, in theolgy and in philosophy of mind over the last 35 years. In this paper I am concerned with what can be described as *horizontal reductionism*: the idea that the cover of natural law, at any one level or crossing all levels, may not be complete; that order may remain to be made in nature by us, not just discovered. The recent philosophical work I draw on is less well understood and concomitantly less regimented than that on vertical reductionism and emergence – open I feel for new perspectives and a new visioning of the kind of order science reveals in nature. That said, one may describe the possibility of making order where none is dictated as a kind of emergentism that it distinct from the conventional one that downward reduction fails. It is one that rests in new considerations about failure of the universal cover of law.

II The Cadres

The reaction against the received view of scientific laws as universal and exceptionless has been as diverse and widespread as the scientific disciplines from which criticisms have been developed. No one view is the same as any other. But they have in common a picture in which laws are not the immutable and exepctionless governors of a nature completely ordered under them. To give just a brief and incomplete overview there are accounts that argue that:

- Laws are ineliminably *ceteris paribus*[1]
- Many basic laws are causal principles that do not describe exceptionlessly regular i.e. totally ordered behaviour[2]
- Laws emerge historically so are not temporarily universal[3]
- The sources of these historically emergent laws are contingent; so the laws too are contingent[4]
- Laws hold only relative to models[5]
- Laws emerge only in structured environments[6]
- Nature is governed not by laws but by powers, capacities and tendencies[7]
- Nature is governed merely by local necessities[8]
- Laws hold with varying degrees and kinds of invariance[9]
- Laws serve primarily as tools or guides to practice[10]
- Laws of science arise as negotiated principles[11]
- Laws of science look univocal and universal but have different meanings for different practitioners or in different circumstances[12]
- The amount of information contained in the history of the universe is not sufficient to compute/ produce precise laws[13]

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[1] Rosenberg 1994, Lipton 1999, Morreau 1999
[2] Steel 2007
[3] Beatty 1995, Gould 1989, Pickering 1984
[4] Beatty 1995
[5] Giere 1999, Heckman 2005, Van Fraassen 1989
[6] Cartwright 1999, Bhaskar 1975, Harré 1993, Lamb 1993, Lawson 1997
[7] Bird 2005, Cartwright 1989, Ellis 2002, Molnar 2003, Mumford 2004
[8] Bechtel and Abrahamsen 2005, Machamer *et al.* 2000**,** Glennan 2002
[9] Dupré 1996
[10] Cartwright, Shomar and Suarez 1995, Mitchell 1997, Woodward 2002
[11] Longino 2001, Galison 1997
[12] Galison 1997
[13] Paul Davies, this volume

To illustrate these kinds of claims I shall here look briefly into studies in two disciplines in the natural sciences – biology and physics.

Biology

Biology has long been criticized: Biology is not a proper science because it does not have proper laws. Now those who study its various practices and the many impressive successes they produce are fighting back. Perhaps the traditional view of what counts as proper science with proper laws has been mistaken all along. Contemporary biology seems to have just what it takes to describe nature successfully and to put its knowledge to use.

Probably two researchers who are most vocal in arguing that this is in general true across biology and even far more widely are John Dupre, head of the UK's ESRC-sponsored Centre for Genomics in Society, and Pittsburgh philosopher of biology, Sandra Mitchell.

Consider Mitchell:

> Take…Mendel's law of segregation. That law says in all sexually reproducing organisms, during gamete formation each member of an allelic pair separates from the other member to form the genetic constitution of an individual gamete. So, there is a 50:50 ratio of alleles in the mass of the gametes. In fact, Mendel's law does not hold universally. We know two unruly facts about this causal structure. First, this rule applied only after the evolution of sexually reproducing organisms, an evolutionary event that, in some sense, need not have occurred. Second, some sexually reproducing organisms don't follow the rule because they experience meiotic drive… Does this mean [that] Mendel's law of segregation is not a "law"? [14]

From hosts of cases in biology like this various authors conclude that rather than good old-fashioned 'proper laws' biology offers instead:

- Laws that emerge historically
- Laws that are contingent.

[14] Mitchell, S. 2002, p. 334

These two come naturally from Mitchell's first two sources of unruliness. They also conclude that biology offers only

- Laws that are not exceptionless.

This is a natural account given Mitchell's second source of unruliness.

Different kinds of cases far from evolutionary biology, in molecular or neurobiology for instance, lead others to propose that biology studies not laws that describe regular behaviour that must occur but rather

- Mechanisms that functioning properly, in the right places, can generate regular behaviour, for instance the interactions of the structures of non-RNA strands with tRNA molecules and ribosomes to underwrite protein synthesis.

Mitchell also points to authors who claim that biology studies

- Ceteris paribus laws, laws that hold only in special circumstances.

She herself advocates something more practical and this is a piece of advice that she proposes to carry outside of biology across the disciplines, from economics to physics:

> We need to rethink the idea of a scientific law pragmatically or functionally, that is, in terms of what scientific laws let us do rather than in terms of some ideal of a law by which to judge the inadequacies of the more common (and very useful) truths [of the kind biology teaches].[15]

Mitchell argues that we should do away with the old dichotomy 'law vs. non-law' or what is universal, exceptionless, immutable versus all the rest, to be replaced by a sliding scale, and along a variety of different dimensions:

> [All] general truths we discover about the world vary with respect to their degree of contingency on the conditions upon which the

[15] Mitchell, S. 2002, p. 333

> relationships described depend. Indeed, it is true that most of the fundamental laws of physics are more generally applicable, i.e. are more stable over changes in context, in space and time, than are the causal relations we discover to hold in the biological world. They are closer to the ideal causal connections that we choose to call 'laws'. Yet, few of even these can escape the need for the ceteris paribus clause to render them logically true.[16]

Looking at how the successes of science are produced across the disciplines, it is truths of varying forms with varying degrees of universality and exceptionlessness, describing various degrees and kinds of order that let us do what we need to do to produce those successes.

Physics

Mitchell's final remarks bring us to physics, which is eventually where the conversation goes when order is challenged: 'Surely the world of physics is totally ordered and if physics is ordered, so is all the rest.' I should begin by emphasizing that the second half of this claim is clearly a mistake. The past 35 years of research I referred to in philosophy and elsewhere on what I called 'downwards reduction' and emergentism shows that we do not have anything like sufficient grounds to assume that physics dictates all the way up.

But our topic here is horizontal reductionism: Does physics offer laws that dictate a complete order among the very kinds of events that physics studies? A number of very different kinds of studies suggest that this is not so.

The first suggest that the laws of physics, in common with all the other laws of science, are ceteris paribus laws. Consider philosopher of physics Marc Lange:

> To state the law of thermal expansion [which states that the change in length of an expanding metal bar is directly proportional to the change in temperature]… one would need to specify not only that no-one is hammering the bar on one end, but also that the bar is not encased on

[16] Mitchell, S. 2002, p. 331

> four of its six sides in a rigid material that will not yield as the bar is heated, and so on.[17]

There is naturally a canonical reply by defenders of the universal rule of physics. The list indicated by 'and so on'

> …is indefinite only if expressed in a language that purportedly avoids terminology from physics, the condition is easily stated: The "law" of thermal expansion is rigorously true if there are no external boundary stresses on the bar throughout the process.[18]

This brings into focus the technical terms of physics, like 'stress'. How far do these stretch? Here the very virtues of physics get it into trouble. The terminology of physics is tightly controlled. This is what distinguishes it from disciplines that hardly count as science at all, that use terminology like 'globalisation' or 'unconscious desire', terms that have no such rigid criteria for their application. There are rules in physics for how to use language, how, for instance, to ascribe a quantum field or a classical force. Rules like $F = GMm/r^2$ when two masses a distance r apart interact. And in most situations there are a number of factors affecting the outcome that we do not know how to describe using these regimented descriptions.

In physics there is no rule that takes you from 'the bar is being hammered' to 'the bar is subject to certain stresses'. The rules for assigning terms like 'stress' require not loose terms of everyday use to apply but a far more technical, regimented vocabulary. Stresses and strains are characterized as forces and force functions have strict rules for application, rules like $F = GMm/r^2$ when two masses r apart interact, $f = \in_0 q_1 q_2/r^2$ when two charges interact, and so forth. And it is not clear that every time a bar is hammered one of these more technical descriptions obtains.

We can *say* that the bar must be under stress because of the way its behaviour is affected. But that reduces physics to the status of psychoanalysis. We can *say* that I have certain unconscious desires because of the odd way my behaviour is affected. A physics that allows us to say things on that kind of basis is not the physics that yields the precise predictions and exact control of nature that gives us reason to think its laws

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[17] Quoted in Earmon, J., Roberts, J.T, & Smith,S. 2002, p. 284
[18] Earmon, J., Roberts, J.T, & Smith,S. 2002, p.284

are true. Better to suppose the laws are ceteris paribus than to deprive them of their power to predict precisely and of the huge empirical support this power provides.

A second kind of study looks at the interactions among different kinds of physicists, for example instrument physicists, experimentalists and theorists. Much of this work comes from the brilliant Harvard historian of physics, Peter Galison, beginning with his studies of neutral currents of the hunt for the Higgs particle, in which he pointed out that experimentalists and theoreticians use many of the same words but they often mean something very different by them. That's because the meaning of the technical terms in physics is given not by single definitions in language antecedently understood but rather by the whole network of assumptions and inferences with other technical terms that can be made using them. Experimentalists and theoreticians make very different assumptions and inferences, caring little about the bulk of what the other says about neutral currents or the Higgs particle and often not understanding it. This is like the well known incommensurability thesis of Thomas Kuhn, with Galison's thick descriptions of the kinds of different assumptions that the experimentalists and theoreticians make about neutral currents or the Higgs particle added on to flesh it out.

What Galison contributes that is really new is his account of how the two groups do communicate, as they do when theoretical claims are tested. The two groups meet in what is analogous to a 'trading zone', where neither's home language is understood by the other. They use between them a trading language – a highly specific linguistic structure 'that fits between the two'. Really a pidgin or perhaps even a Creole. Galison stresses that he intends 'the pidginization and Creolization of scientific language to be treated seriously just the way one would address such issues for language more generally'[19], not as a loose metaphor.

This is a nice solution to the incommensurability problem that rings true to the historical descriptions Galison provides. But pidginization raises real problems for the traditional account of laws. The laws of physics are supposed to be universal and comprehensive, but they are also supposed to be well tested. So which laws are these? It is the theoreticians' laws, fitting together into an integrated theoretical package, that have a claim to be

[19] Galison, in Krige, J. & Pestre, D., 1997, p.675

comprehensive; it is the experimental laws with their connections to all the requisite experimentalist assumptions that are tested. And the pidgin laws will generally not have enough back up from the home languages to do either. There is a plurality of laws here and together they serve our pragmatic needs, as Sandra Mitchell urges. Picking, choosing and combining, we can do what we need to do. But there is no set of well-tested laws that looks comprehensive enough to support total order in the domain of physics.

My own work on testing, evidence and induction in physics fits well with the Galison story. The dramatic empirical successes of modern physics, both its precise experimental predictions and its fantastic technological applications, undoubtedly provide evidence for very concrete detailed kinds of physics claims, claims that are much like blue prints for how the apparatus operates. These claims are not a-theoretical in any way – the laser pumps a population of atoms into an *inverted quantum state*. But they are very detailed – that's how we get the operation of the device just right – and in mixed vocabulary, from different branches of physics and from pure and applied engineering at all different levels. The problem is that these detailed claims do not relate in the right way for inductive support to flow upwards to the most fundamental laws of physics, at least if the fundamental laws are taken in the traditional way as claims of universal scope. The picture I am left with is a world of physics that is ordered very precisely and very tightly, but in patches, and with gauzy edges. That is what I describe in my book *The Dappled World: A Study of the Boundaries of Science*[20]. The title is taken from the Gerard Manley Hopkins poem 'Pied Beauty'

> Glory be to God for dappled things-
> For skies of couple –colour as a brindled cow…

Were my book alone, I would still immodestly be urging that the breakdown of the traditional image of the completely ordered universe projected from science should be taken very seriously. But my work is not at all alone. My approach is just one among what is now a large and diverse body of work that sees science operating across the board very differently from the traditional image of universal laws and complete order.

[20] Cartwright, N. 1999

I would not want to claim that all of this work is uncontroversial. Nor do many of the authors draw the kinds of general conclusions I do here. Most restrict their conclusions to the specific practices they study in the specific disciplines they know intimately. What is impressive is how many such studies there are and how many different disciplines they span. It is as if, once the idea has broken down that the successes of modern science speak for the universal rule of law and the complete order of nature the flaws in the usual account can be seen here, there and everywhere. The point is that these studies are widespread, detailed and diverse, by serious scholars seriously trying to account for how the sciences work. Though perhaps controversial, they should not be ignored, neither in our attempts to understand the world nor in our attempts to understand God and His intentions about our responsibility for the order of nature.

Others too have noted the implications of the new pictures of nature, the nature of God and God's relation to man. In a recent book Owen Gingerich[21] argues that these new groundbreaking views of nature as not universally law-governed fit particularly well with his claim that God judiciously intervenes in nature at key points to direct its ends. This adds support to his impassioned argument that science and theism be viewed as compatible and complementary.

III What follows?

I close with a very brief sketch of the kinds of theological problems I think we must now face up to.

Since at least the Scientific Revolution three theses have marched hand in hand:

- God has created a perfect world fine-tuned to his ends.

The perfection of God's plan has been taken to be reflected in the fact that

- There is a universal and complete order in nature.

Because of its complete and perfect order,

- What happens in nature can be described in universal and exceptionless laws.

[21] Gingerich, O., 2006

Generally these complete and exceptionless laws have been taken to be mathematical, though there have been notable exceptions such as the Romantic movement that extolled the variety and complexity of nature and A.N. Whitehead and his fellow thinkers at the turn of the last century who took the biological as the basic order.

There have been over two centuries of questioning whether nature needs God as its source. But little doubt that if God is the source of nature, it is a perfect nature whose perfection is revealed in its complete and universal order, an order that can be described in exceptionless laws. So the second and third theses have remained intact until very recently. But as we have seen, in the last decade and a half the quiet revolution about the character of the laws of nature and the order they describe casts serious doubts on whether the sciences do indeed describe a uniformly law-governed world.

But if the canonical assumptions of the second and third theses are to be called into question, then it is natural to inquire into the implications this new picture has for understanding the nature of God's perfection and God's role versus the responsibility God assigns to us in the unfolding and fine-tuning of nature. The revolution in contemporary history and philosophy of science introduces the possibility that it was a mistake to assert the link between God's perfection and His omnipotence on the one hand and the complete and uniform order in nature on the other. Once we, like Gerard Manley Hopkins, are freed from the assumption that perfection must come in the form of exceptionless regularity, we can consider alternative senses in which the world could be ordered. We can also ask how such alternative kinds of order are consistent with the idea that God finetunes nature to direct what emerges, as well as what lessons follow about His intentions for man's role in nature. If God made a universe in which much of the creation of order is left to man, what conclusions should we draw about the nature of God and his perfections, of God's relation to man and the universe, and of man's responsibilities in the universe?

REFERENCES

Beatty, John. 1995, 'The Evolutionary Contingency Thesis.' In Gereon Wolters and James G. Lennox (eds.), *Concepts, Theories, and Rationality in the Biological Sciences*, The Second Pittsburgh-Konstanz Colloquium in the Philosophy of Science, University of Pittsburgh Press.

Bechtel, W. and Abrahamsen, A. 2005, 'Explanation: A mechanistic alternative', *Studies in History and Philosophy of the Biological and Biomedical Sciences* , 36, 421-441.

Bhaskar, R. 1975, *A Realist Theory of Science*, Leeds Books Ltd.

Bird, A. 2005 'The Dispositionalist Conception of Laws', *Foundations of Science*, 10, 353-370.

Cartwright, N. 1989, *Nature's Capacities and their Measurement*, Oxford University Press.

Cartwright, N. 1999, *The Dappled World: A Study of the Boundaries of Science*, Cambridge University Press.

Cartwright, N., Shomar, T. & Suarez, M, 1995, 'The Tool-box of Science' *Poznan Studies in the Philosophy of the Sciences and Humanities.*

Dupré, J. 1996, *The Disorder of Things: Metaphysical Foundations of the Disunity of Science*, Harvard University Press.

Earmon, J., Roberts, J.T, & Smith,S. 2002, '*Ceteris Paribus* Lost', *Erkenntnis*, Vol. 57, No.3, pp. 281-301.

Ellis, B. 2002, *The Philosophy of Nature: A Guide to the New Essentialism*, McGill-Queen's University Press.

Galison, P. 1997, *Image and Logic: A Material Culture of Microphysics*, University of Chicago Press.

Galison, ‘Material Culture, Theoretical Culture and Delocalization’, in Krige, J. & Pestre, D. 1997, *Science in the Twentieth Century*, Harwood Academic Publishers

Giere, R. 1999, *Science Without Laws*, University of Chicago Press.

Glennan, S. 2002, ‘Rethinking Mechanistic Explanation’, *Philosophy of Science*, 69, S342 -S353.

Gingerich, O. 2006, *God’s Universe*, Belknap Press.

Gould, S. J. 1989, *Wonderful Life: The Burgess Shale and the Nature of History*, W. W. Norton & Co..

Harré, R. 1993, *Laws of Nature*, Duckworth.

Heckman, J. 2005, ‘The Scientific Model of Causality’, *Sociological Methodology*, 35: 1–97.

Lamb W. 1993, ‘Quantum Theory of Measurment’, Three Lectures, London School of Economics, July 1993.

Lawson, T. 1997, *Economics and Reality*, Routledge.

Lipton, P, 1999,‘All Else Being Equal’, *Philosophy*, 74, 155–168.

Longino, H. 2001, *The Fate of Knowledge*. Princeton: Princeton University Press

Machamer, P., Darden, L., Craver, C. 2000, ‘Thinking about Mechanisms’, *Philosophy of Science*, 67, 1-25.

Mitchell, S.D. 1997, ‘Pragmatic Laws’, in L. Darden (ed.), PSA 1996: Part II, Symposia. Papers, *Philosophy of Science* (special issue), S468–S479.

Mitchell, S. 2002 ‘Ceteris Paribus – An Inadequate Representation For Biological Contingency’ *Erkenntnis*, Vol.57, No.3, pp. 329-350.

Molnar, G. 2003, *Powers: a Study in Metaphysics*, Oxford University Press.

Morreau, M. 1999, ‘Other Things Being Equal’, *Philosophical Studies*, 96, 163–182.

Mumford, S. 2004, *Laws in Nature* ,Routledge.

Pickering, A. 1984, *Constructing Quarks*, University of Chicago Press.

Rosenberg, A. 1994*, Instrumental Biology or the Disunity of Science*, University of Chicago Press.

Steel, D. 2008*, Across the Boundaries: Extrapolation in Biology and Social Science*, Oxford University Press.

Van Fraassen, B. 1989, *Laws and Symmetry*, Oxford University Press.

Woodward, J. 2002, ‘There is No Such Thing as a Ceteris Paribus Law’, *Erkenntnis*, 57, 3, p. 303-328.