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(eds): Brute Facts, Emergence, and Scientific
Explanation**

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*Elly Vintiadis, Constantin Mekios (eds):
Brute Facts, Emergence, and Scientific
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Elly Vintiadis, Constantin Mekios (eds): *Brute Facts, Emergence, and Scientific Explanation*

Brute Facts. Oxford University Press, Oxford, 2018 (ISBN: 978-0-19-875860-0) (Hardback), 288 Pages, Price: £50 (Hardback), £35.63 (eBook)

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According to Leibniz, every truth has an explanation, by virtue of the principle of sufficient reason (PSR), according to which “nothing happens without a reason why it should be so, rather than otherwise” (Monadology, §32, quoted by Vintiadis, p. 3). If everything has a “sufficient reason”, and if a fact is brute if and only if it has no explanation, it might seem to follow that there are no brute facts. The 14 contributions to the collection *Brute Facts*, edited by Elly Vintiadis and Constantin Mekios, provide a wide range of deep and sophisticated philosophical reflections on the limits of scientific explanation. If, as John Symons argues in his contribution to the book, there is no good reason to accept the PSR as a universal metaphysical truth, although it is a useful methodological and heuristic principle, we are faced with the baffling and fascinating possibility that some facts are brute. Explanations are arguments produced by human subjects in particular circumstances. Facts that do not have an explanation in a given historical context, and are thus “epistemically brute”, may nevertheless be explained later on, thanks to scientific progress. One is naturally led to ask whether some facts are absolutely brute rather than only relatively to a particular historical context. Are there “ontologically brute facts” (p. 2) that could not possibly ever be explained? While it may be unhappy to call them “ontologically unexplainable” (p. 2), the notion of such absolutely brute facts is explored in metaphysical terms by various authors in the book, by construing them (as Torin Alter) as ungrounded facts or (as Dana Goswick) as fundamental facts.

Here is an example of the sophisticated and deep philosophical thoughts provided by the authors of the book. It is often assumed that explanation is inseparable from understanding so that ontologically brute facts cannot possibly be understood. According to Hempel and Oppenheim’s deductive-nomological model of explanation, an explanation provides understanding for a given fact by showing that there is a logically valid argument whose conclusion

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is a proposition expressing this fact. On this model, brute facts cannot be explained because there are no more fundamental premises from which they could be derived. However, Peter Wyss challenges the equivalence of lack of explanation and lack of understanding: learning that something is a brute fact yields understanding. We know more when we know that there is no explanation to be found.

A large part of the book is dedicated to a particular sort of brute facts, i.e. emergent facts. This choice may surprise a reader who expects that metaphysicians and philosophers of science would first of all be interested in the brute character of fundamental facts of physics, both particular facts, such as the fact that the speed of light in the vacuum is c , and laws such as Maxwell's laws or Einstein's field equations of General Relativity. However, such facts and laws are hardly mentioned in the book (John Heil's chapter is an exception), whereas questions arising in the context of emergent properties and laws occupy centre stage in many chapters. A property of a complex system is said to be emergent if it (1) gives the system "novel" causal powers that none of the system's constituents has and (2) is irreducible in principle in terms of the properties of these constituents and their relations. It is controversial whether emergent facts fall in the domain of brute facts. Indeed, some authors, such as Bickhard, argue that emergence "does not require nor support brute facts" (p. 245).

The emergence of conscious states in humans, from physical states of their bodies, is the most widely discussed case of emergence. There are important challenges against the plausibility and even the coherence and intelligibility of the existence of emergent properties and facts, in the context of physicalism and such principles as the supervenience of all facts on the physical facts, and methodological naturalism, according to which there is no limit in principle to scientific explanation. Several chapters in the book address these challenges and argue for the compatibility of emergent brute facts with at least some of these principles.

The order of the chapters in the book follows a clear plan. Beginning with general metaphysical (Heil) and epistemological (Taylor) analyses of bruteness, the following chapters discuss particular sorts of brute facts: normative (Bickhard), moral (Levine), modal (van Cleve, Goswick), and emergent facts (or emergent laws, discussed by Vintiadis), in particular facts about phenomenal experience (Alter). Let me say a few words on each chapter.

In the opening chapter, John Heil ties the question of whether there are brute facts to the questions whether there are brute laws and whether laws flow from reality's brute powers, and ultimately to the issue of the bruteness of reality itself. Heil arrives at the conclusion that there is much less bruteness in reality than Humean metaphysics makes it appear. Reality itself might be the only brute thing there is; for all other apparently contingent facts, they might only appear as brute from the point of view of Humean metaphysics. Thus, the source of their apparent bruteness might lie "in ourselves" (p. 27).

Elanor Taylor shows that making the case for a fact's being ontologically brute requires showing (1) that there is no explanation of that fact, for even fundamental facts may have explanations, e.g. in terms of other fundamental facts, furthermore (2) that no explanation of any sort will be forthcoming in the future, and (3) that the absence of any explanation fits into a larger philosophical and scientific worldview. The metaphysical hypothesis that a given fact is ontologically brute must be justified by an abductive argument, in a way analogous to the justification of scientific theories.

Joseph Levine makes an illuminating case for the existence of brute moral facts. "There is something extra in the world, normative force, that is not guaranteed by the non-normative properties and logic" (p. 61). On the basis of a subtle argument, in which he compares moral facts with another important type of brute facts, i.e. facts of phenomenal experience, Levine

concludes that the bruteness of the supervenience of phenomenal facts is only apparent (or epistemic), in the sense that it stems from our concepts, whereas the bruteness of the supervenience of moral facts is real or metaphysical.

James van Cleve explores the question whether there are brute modal facts, and in particular, necessary facts. Essentialists, such as Kit Fine and Gideon Rosen, propose to explain necessary truths by essences: if p is necessarily true, this necessity follows from the fact that it is in the nature of some object x that p is true. However, a consequence van Cleve draws from Fine's and Rosen's principles, namely, that those essences are themselves explained by higher order essences, leads to an infinite regress. In order to block this regress, Dasgupta has proposed that essences are autonomous. A fact is "autonomous" if it has no explanation but also need not any. For van Cleve, a fact is "brute" if it does not have any explanation although it would require one. Van Cleve accepts Gupta's proposal and adds that it might yield a reason to think that all necessary truths are autonomous.

The section in van Cleve's chapter on what is maybe the best known brute fact of all, the bruteness of the emergence of phenomenal facts from physical facts about the brain, is strangely inconclusive. It looks as if he did not use the results of the other sections to shed more light on this one. The section ends with the question whether an explanation of the emergence of phenomenal facts m from their physical grounds p by the identity of those facts ($p = m$) could make the mystery even bigger: identities may be unexplained and mysterious; therefore, the emergence of m from p might not really be explained by the fact that $p = m$.

Three other sections (on mathematical explanation, on brute necessity in ethics, where he argues that, on Moore's conception of ethics, there are necessary normative truths that are either autonomous or brute, and on the view that some necessary truths are either autonomous or intrinsically explained and that the rest are explained by necessary truths of these two sorts) of van Cleve's paper do not appear in the book—the reader is invited to read them in the longer version of the chapter that has been published as "Brute Necessity", *Philosophy Compass* 13, 9 (2018) and is available on the author's website.

Van Cleve's overview of various accounts of whether necessary truths have or need explanations is rich and subtle, but van Cleve's result might seem weak: "the mind-body problem and ethics (...) (are) two arenas in which some philosophers may find and accept brute necessities" (p. 92). His exploration of the different ways in which the postulate of brute (or autonomous) necessary truths may be avoided is illuminating and indirectly sheds light on the concept of brute necessity itself: for example, views according to which every necessary truth can be explained by a higher order necessary truth lead to an infinite regress, which makes it doubtful whether there is any explanation in the first place. Thus, it turns out that on such a view, necessary truths are brute or autonomous after all.

Dana Goswick proposes a reductive account of *de re* modal facts. She elaborates an original strategy for reducing what she calls "modal objects". Instead of trying to reduce an object's modal properties to non-modal properties, Goswick construes modal objects as mereological sums of non-modal objects and sortal properties. She considers a realist and a non-realist version of such a view: according to her own non-realist version, a non-modal object and a sortal property s together compose a modal object if and only if a subject has the s -response to the non-modal object. According to this response-dependent theory of the existence of modal objects, it "isn't a deep objective, subject-independent feature of the world. It's a feature about us, our interests and our concerns" (p. 109). Goswick's thesis that *de re* modality is grounded in human responses may be challenged along the following lines. (1) The fact that a subject reacts to a given object or situation with an s -response is a fact about the subject's dispositions,

which seems to make it a modal fact, just as the object's affordance for an *s*-response is dispositional and modal. Even if Goswick's account of modality is correct, it does not hold its promise of reducing modal facts to something non-modal, because it reduces modal facts about objects to modal facts about subjects. The modal fact that a subject has an *s*-response seems to raise the same challenge that her account was intended to meet, i.e. the challenge of reducing modal facts to something non modal. (2) Goswick judges that (a) "there is no room for primitive modality" (p. 102) in a worldview compatible with naturalism and that (b) modality is grounded in subjects' responses. However, the naturalist perspective Goswick endorses might warrant the opposite conclusion that modality is inseparable from the scientific worldview and thus that the acceptance of the existence of modality is part of naturalism.

Kevin Morris' chapter critically examines a recent attempt by Cameron and Barnes (Ross Cameron and Elizabeth Barnes, *A Critical Study of John Heil's From an Ontological Point of View. SWIF Philosophy of Mind Review* 6 (2007), p. 22–30) to make sense of emergence in terms of truthmaking. According to most interpretations of the concept of emergence, emergent properties are determined by more fundamental properties in a brute way, i.e. in a way that cannot be further illuminated, scientifically or otherwise. Such "brute determination" (p. 121) seems to be incompatible with naturalism, according to which everything non-fundamental can at least in principle be scientifically explained. Morris examines the attempt (by Cameron and Barnes) to escape this problem by showing that emergent properties are needed as truthmakers, thereby making the justification of the postulate of emergent properties independent from the relation between these emergent properties and more fundamental properties on which they may depend or on which they may supervene.

To assess this claim, Morris distinguishes two sorts of emergent properties: (1) properties that are ontologically dependent on other properties, in the sense that they cannot be exemplified alone, but are neither supervenient on other properties nor metaphysically necessitated by other properties (having mass may be such a property) and (2) properties that are so necessitated. Morris argues that emergent properties of type (1) can indeed be defended against the challenges that have been raised against them, but that this defence is independent of their justification as truthmakers. Instead, what makes their defence possible is the fact that properties of type (1) are not metaphysically necessitated by (or supervenient on) more fundamental properties.

However, according to Morris, the construal of emergent properties in terms of truthmaking does not help overcoming the challenges that have been raised against emergent properties of type (2). In particular, their construal as truthmakers does not help understanding how such properties can make a distinctive causal contribution in addition to the properties by which they are metaphysically necessitated.

These are subtle matters, and Morris' analysis can be challenged. Kim (*Philosophy of Mind*, 2d edition. Cambridge, MA: Westview, 2006, p. 12) has shown that supervenience, if defined in terms of correlation, does not entail metaphysical necessitation. Supervenient properties need not be metaphysically determined by the properties in the supervenience base: the correlation between the supervenient properties and those on their base may be brute, or properties of both sets may be determined by properties in a third set. If Kim is right about this, there are 3 types of metaphysical dependence of properties on other properties. Emergent properties might fall in Morris' category of "dependences" (dependence in the sense of having a supervenience base), *without* being metaphysically necessitated by other (more fundamental) properties. For emergent properties of that sort, construing them as truthmakers may be successful in showing how they can make a distinctive causal contribution (although they

are supervenient on more fundamental properties) and maybe also escape other challenges that have been raised against emergent properties.

Torin Alter argues that we are not at present in a position to assess whether there are brute phenomenal facts. He shows that anti-materialist arguments such as Jackson's knowledge argument, even if sound, are not sufficient to establish the existence of brute phenomenal facts. The knowledge argument shows that comprehensive physical knowledge is incomplete: there are phenomenal facts that cannot be known on the mere basis of reasoning from (hypothetical) comprehensive physical knowledge. Alter's demonstration relies on a doctrine called "Russellian panprotopsychism" recently developed by David Chalmers. According to this doctrine, there are "intrinsic properties underlying basic structural-and-dynamic properties described by physics", called "quiddities", which are "protophenomenal" (p. 137). The doctrine rests on the hypothesis that these properties "collectively constitute phenomenal properties when organized in the appropriate way" (David J. Chalmers, *The Character of Consciousness*. New York: Oxford University Press, 2010, p. 151). The mere coherence of this doctrine is sufficient to show that even if the knowledge argument is sound, its soundness is not sufficient to show that there are brute phenomenal facts. The phenomenal facts that cannot, according to the knowledge argument, be derived from scientific knowledge may not be brute because they may be grounded on protophenomenal facts.

Alter's argument crucially depends on the coherence of Russellian panprotopsychism (or some other doctrine playing an equivalent logical role). He shows that two prominent critics of Russellian panprotopsychism (P. Goff and G. Strawson who defends panpsychism against panprotopsychism) do not succeed in establishing that it is incoherent. Alter's demonstration is impeccable according to which (1) Russellian protopsychism is "viable" (p. 148) and therefore (2) we should remain agnostic about the existence of brute phenomenal facts. However, I would challenge his claim that "we should not conclude that this view is implausible" (p. 144). The truth of Russellian protopsychism (or some other doctrine playing its role) seems to be a mere logical possibility. We have no positive reason to think it is plausible. If this is so, Alter's demonstration appears as a purely academic exercise of conceptual analysis, which has no bearing on the question whether complete scientific knowledge would be sufficient to understand phenomenal facts. Given that we have no positive reasons to believe that there are protophenomenal facts, their mere logical possibility gives us reasons neither for nor against the hypothesis that there are brute phenomenal facts. The hypothesis of Russellian protopsychism may turn out to be just a sophisticated way of expressing (but not justifying) the intuition that science is incomplete in principle, for the plausibility or truth of which we have been given no positive reasons.

Gerald Vision defends emergentism construed as the thesis that conscious states emerge "from wholly material circumstances" (p. 156), where emergence is taken to be a "brute connection" (p. 157). His strategy for defending the intelligibility and plausibility of this thesis consists in challenging panpsychism. Contemporary justifications of panpsychism, in particular by G. Strawson and D. Chalmers, start from the premise that the existence of conscious states can only be explained in two ways, either consciousness (or protoconsciousness, according to Chalmers) is among the fundamental properties of (at least some) fundamental particles or it is not. In the former case, the existence of conscious states in humans and certain animals can be explained as arising from the primitive consciousness of fundamental particles; in the latter case, it can only be explained with the help of emergence. Panpsychists argue that the former alternative is more plausible whereas the latter is either implausible or unintelligible. Emergentists argue on the contrary that panpsychism is at least implausible.

Panpsychists point out that emergentism requires the postulate of brute connections whereas panpsychism need not because it takes consciousness to be a brute property of fundamental particles. Given its existence, no brute *connection* between fundamental facts and non-fundamental facts needs to be postulated. Emergentism must postulate such brute connections in order to be able to explain the existence of conscious states in a world without any conscious (or protoconscious) fundamental states and properties. Vision argues that none of the reasons that have been offered for thinking that such brute connections are unintelligible or implausible can be derived “from an overview of scientific practice” (p. 166). On the contrary, current scientific knowledge warrants the emergentist thesis of the existence of brute connections between brain states and conscious states. Panpsychism faces its own difficulties. Chalmers’ variant of panpsychism seems itself to require emergence: the relation between protophenomenal and phenomenal properties seems to be a relation of brute emergence, just as the relation between neural properties of the brain and phenomenal properties of experiences. This is related to the “combination problem”, which has been raised by William James. How do the conscious states of the particles constituting us “coalesce into the transparent and simple experiences we undergo”? (p. 172).

The overall objective of John Symons’ chapter is to show that the existence of strongly emergent properties is compatible with an appropriate interpretation of the principle of sufficient reason (PSR), according to which everything has an explanation. The acceptance of emergence is not necessarily incompatible with scientific rationality for two reasons. (1) There can be scientific reasons for accepting emergence, so that scientific rationality does not necessarily favour physicalism over emergentism. Here is an argument for the impossibility to reduce all chemical facts in physical terms. The chemical differences between isomers, such as methyl ether and ethanol, cannot be explained in terms of quantum mechanics, given that isomers share their Hamiltonian. Methyl ether and ethanol are isomers because they are “molecules with the same kinds and number of atoms, but with different molecular structures” (p. 183). So even if it is true that contemporary science makes the British Emergentists (Samuel Alexander, Lloyd Morgan, C.D. Broad) appear wrong about their examples of emergent properties, it warrants the characterization of other properties as emergent. (2) It is possible and indeed rational to accept the PSR as “a methodological heuristic for scientific inquiry” but not “as a metaphysical principle governing Being” (p. 178).

The common ground shared by physicalists and emergentists is the acceptance of the methodological principle that the existence of unexplained brute facts should be (just as anything else) accepted “only on the basis of empirical considerations” (p. 190). However, physicalism is usually defined with the help of metaphysical principles for which it is not obvious whether or how they can be justified by empirical or scientific considerations. How could science justify the principle “that the physical world is causally closed” (p. 190), given that causation is a metaphysical concept that is used in science but whose analysis cannot be found in science? The same question can be asked for the so-called “Hume’s dictum”, according to which “there are no metaphysically necessary connections between distinct, intrinsically typed entities” (Jessica Wilson, What is Hume’s Dictum, and Why Believe It?, *Philosophy and Phenomenological Research* 80 (2010), p. 595–637). In fact, science seems to provide reasons for doubting that Hume’s dictum is universally valid: it seems, e.g. to be contradicted by relations between parts of entangled quantum systems. Furthermore, the physicalist claim that the facts taken into account by present day physics, or even by an ideal physics of the future, are complete cannot possibly be warranted by (present day) science. Symons concludes that the best interpretation of the PSR is to accept it as a methodological heuristic that underlies and justifies a sceptical

reaction to brute facts. However, only an interpretation of the PSR as a metaphysical principle would justify physicalism as a metaphysical doctrine, but such an interpretation is not justified.

Elly Vintiadis argues for the plausibility of the existence of emergent brute facts. A strategy similar to John Symons' leads her to a stronger conclusion. According to Vintiadis, we have empirical reasons for believing that there are irreducible brute trans-ordinal laws, in particular laws linking brain states to conscious states. If this is correct, the "explanatory gap" is not only epistemic as Joseph Levine has argued in "Materialism and Qualia: The Explanatory Gap", *Pacific Philosophical Quarterly* 64 (1983), p. 354–361, but corresponds to a "metaphysical gap" (Vintiadis, p. 210) between physical facts and consciousness, which is therefore a "non-physical ontological brute fact" (p. 210). Vintiadis analyses three arguments that physicalists have put forward against the existence of emergent brute facts. One of them is the "coherence argument" according to which the emergentist position contains the incoherent claim that emergent facts are both dependent on other, more fundamental facts, and yet distinct from them. In her rebuttal of this argument, Vintiadis suggests that what is crucial for determining whether the dependence of emergent facts on more fundamental facts is coherent with their distinctness from those facts is the status of the laws linking the fundamental and emergent facts. She suggests that these interlevel or "trans-ordinal" laws may be themselves emergent and thus brute. This would make emergent bruteness acceptable insofar as everyone (including physicalists) has to accept the existence of brute fundamental laws (of physics).

The bruteness of trans-ordinal laws "is no worse than any other bruteness of fundamental facts that are accepted by physicalists" (p. 202). However, this claim may be challenged. The existence of brute trans-ordinal laws is certainly a logical possibility but it would require a different sort of justification than the existence of fundamental physical laws. In the case of the latter, the burden of proof seems to lie on those who deny their being fundamental, because we do not know any more fundamental facts and laws to which they might be reduced. In the case of trans-ordinal laws, the burden of proof seems to lie on the emergentist who holds that they are brute, i.e. can in principle not be reduced, because in the case of these laws, we know more fundamental facts and laws. The alternative to accepting fundamental physical laws is the hypothesis that there is no fundamental level at all but rather an infinite series of levels. It is hard to find positive reasons that would warrant the latter hypothesis. The alternative to the existence of brute trans-ordinal laws is the hypothesis that trans-ordinal laws can always be reductively derived from lower level laws. The existence of reductive explanations such as the explanation of the stability of the dihydrogen ion H_2^+ from quantum mechanical principles gives some inductive support to the latter hypothesis, even if it is of course not conclusive.

Peter Wyss' contribution sheds original light on emergence by showing that "emergence can have a useful epistemic function" (p. 214). Against Hempel and Oppenheim's claim that emergentism "encourages an attitude of resignation which is stifling for research" (Carl G. Hempel and Paul Oppenheim, "Studies in the Logic of Explanation", *Philosophy of Science* 15 (1948), p. 135–75, p. 152), Wyss argues that "brute facts (...) can provide insights, understanding, and perhaps even explanations" (p. 215). He distinguishes two questions about emergence, to which correspond two types of informative answers. One can ask, first, why something emerges in a particular context, i.e. what are the sufficient conditions for its emergence. And one can ask, second, "why this emergent arises rather than another one" (p. 216), i.e. focus on the identity of what emerges. That the search for an answer to the first question "drives" (p. 220) research rather than "stifling" it can be seen from the fruitful research in neuroscience about the conditions for the emergence of consciousness. However, what makes the postulate of emergent properties positively explanatory is the way science

explains their identity and their causal influence. Answers to the second question cannot be found at the level of properties and laws on which emergent properties are grounded: according to what Wyss calls “the identity approach” (p. 222) to emergence, emergent entities are “individuated through their active and passive powers, that is, by what they cause and what they are caused by” (p. 224). Emergent entities are postulated because they are required to account for “new systematic patterns of causality” (p. 224) that correspond to “distinctive laws associated with the emergents” (224). The causal powers and laws that come into being together with an emergent entity justify the idea that it belongs to a “higher ontological level” (224) than its basis.

The impossibility to derive an emergent entity from its basis provides an epistemic advantage: by acknowledging that a fact is brute, we obtain the epistemic gain of learning that there is no mystery left to be resolved. Wyss is led to a provocative re-evaluation of Samuel Alexander’s idea that emergent entities have to be accepted with “natural piety”. Rather than joining the choir of philosophers who have, beginning with Alexander’s contemporaries and even C.D. Broad, blamed “natural piety” for being anti-scientific, Wyss recommends interpreting it as an expression of “epistemic modesty, or humility” (p. 228). “Natural piety” is not only compatible with a naturalistic attitude, but it is a helpful and constructive part of scientific method. “It is epistemically virtuous to stop unanswerable questions” (p. 229): once something has been recognized as emergent, waste of energy is avoided by redirecting research away from questions that are known to have no answer. Knowing that something is emergent is an illuminating second-order epistemic state, and “natural piety is (...) a meta-theoretical policy not to overreach our epistemic grasp” (p. 230). Not everything in Wyss’ fascinating contribution is perfectly clear. One of his projects is to downplay the traditional distinction between epistemic and ontological emergence (p. 219), but even on this background, it is hard to make sense of what he calls “ontological reduction” (222) and “(ontological) irreducibility” (221). As long as Wyss does not provide a new definition of the concept of reduction, it is epistemic not ontological: reduction has been defined in different ways, among others by Ernest Nagel (*The Structure of Science*, London, Routledge and Kegan Paul, 1961) and Thomas Nickles, Two concepts of intertheoretic reduction, *The Journal of Philosophy* 70 (1973), p. 181–201 but always in epistemic terms.

Mark Bickhard’s ambitious contribution sketches a model of emergence that “does not require nor support brute facts” (245). He shows that Kim’s famous argument against emergence relies on the assumption that the microphysical world is causally closed and that it is possible to account for causality at that level in terms of microphysical particles and their causal powers. This framework is not warranted by contemporary physics. Bickhard argues that a process metaphysics is more adequate to contemporary physics, according to which “there are no particles; everything is fields – quantum fields” (237). Then he sketches a model for the emergence of normativity, which is the basis of the emergence of representation and cognition. Hume’s argument against deriving norms from facts is valid but unsound: norms can be implicitly defined. Bickhard suggests that the fundamental normative asymmetry is between functional and dysfunctional and that it can be defined within process metaphysics in terms of the persistence or stability of far from equilibrium processes. Self-maintaining processes make functional contributions to their own persistence. A candle flame and a bacterium swimming up a sugar gradient provide illustrations of such processes. Representational normativity, which is the ground for all forms of cognition, arises from functional normativity. Bickhard’s sketch of a model of emergence that does neither require nor support brute facts or brute laws is fascinating, but the reader is invited to consult other works of Bickhard’s to learn about the details. His framework makes the issue of the existence of brute

facts independent of the issue of emergence. Naturalism does not prejudge the question of brute facts in one sense or the other.

Arnellos and El-Hani sketch “a conception of ontological emergence according to which certain types of dynamical organizations possess irreducible properties that are nevertheless derivable from the substrate” (p. 249). They seem to hesitate whether their analysis should be interpreted in a realist way. On one hand, according to one of the authors (El-Hani), “ontological emergence” should be understood to be a feature not of the world but of scientific models (p. 249, note 1), but on the other hand, the cohesion of a persistent emergent system “is a causal property of the system itself, not merely a property of our description or conception of the system, i.e. it is an ontological rather than epistemological feature” (p. 260, note 16). Like Bickhard, they argue that emergence does not imply bruteness: “there is absolutely nothing brute in the emergence of such organizations” (p. 248). Arnellos and El-Hani make the surprising claim that emergent features of stable systems such as “constancy, persistence and resilience” (p. 250) are irreducible *without* being unexplainable and thus brute (p. 250). They work with a concept of reducibility as identity, so that irreducibility is compatible with explanation.

Arnellos and El-Hani argue that the supervenience of emergent properties of organized systems on the properties of the constituent parts may fail. In the case of fusion, the reason is that the constituent parts disappear during the appearance of the emergent property; in the case of organized systems, the reason is that the configuration of their parts is not part of the supervenience base. They distinguish the supervenience base from the emergence base (p. 257): the parts, together with their properties, are necessary but not sufficient for some emergent property. To reach a sufficient condition, the configuration of the parts must be added. It is a terminological choice to count the configuration as part of the emergence base but not as part of the supervenience base. However, the controversial result that emergents are not supervenient could be avoided by including the configuration of the parts in the supervenience base.

Arnellos and El-Hani justify the claim that organizational features of dynamical systems are emergent by their novel causal powers to act on the constitutive parts of the system by downward causation. Downward causation, which they call “medium DC” (p. 260), is explicitly distinguished from productive causation and conceived in terms of constraints. The organization constrains the number of degrees of freedom of the evolution of the constituent parts. Within these constraints, which exercise a “neo-Aristotelian (...) formal causal influence” (p. 261) on the parts and which they conceive in terms of probability raising, physical-level causation determines the evolution of the parts, so that the principle of the causal closure of the physical can be respected. Their choice of probability-raising as the appropriate model of causal influence is not explicitly motivated and seems independent of their analysis of DC. They could just as well have used other models, such as structural equations or counterfactuals.

The book is a collection of independent papers. In her very useful introduction, Vintiadis puts the papers collected in the volume in a common perspective, but the editors have not attempted more integration, by encouraging the authors of the chapters to engage in a debate with each other or by trying to impose a homogenous terminology. The word “brute” is a case in point: some authors distinguish “brute” from “fundamental”, some do not. The former choice is explicitly adopted, e.g., by Taylor who justifies this distinction by pointing out that not all fundamental facts are brute: fundamental facts may have explanations, e.g. in terms of other fundamental facts, whereas brute facts have no explanation whatsoever. The latter

terminological choice is explicitly adopted, e.g., by Alter: "I use 'brute' and 'fundamental' interchangeably" (p. 131).

The authors disagree on many points. It would have been interesting to see the authors of the different chapters debate at least sometimes with each other. To mention just a few points of disagreement, Heil and Levine argue that only contingent facts can be brute whereas van Cleve argues that there may also be brute necessities, e.g. in mathematics, where they coexist with necessary truths that can be explained. Wyss argues that an attitude of natural piety towards emergent facts may be epistemically valuable, whereas Arnellos and El-Hani judge that emergence, at least in biology "cannot be accepted with 'natural piety'; rather it must be explained" (249). Most authors accept that emergent properties of some complex system supervene on the properties of the parts of the system, together with the relations between these parts, but Arnellos and El-Hani have "abandoned the conception of emergents as supervenients" (p. 266).

Points of convergence are not explicitly mentioned either. Wyss' suggestion that "one strategy to explain epistemic gaps is the appeal to metaphysical gaps" (p. 223) parallels Vintiadis' idea that "there is an explanatory gap because there is a metaphysical gap" (p. 210). Similarly, Wyss' observation that "we ought to postulate not as few entities as possible, say, but as many as necessary" (p. 230) might be compared to Vintiadis' remark that "the real question is not which view posits fewer brute facts, it is how many (or what kind of) brute facts we need to yield the best description and, when possible, explanation of a phenomenon" (p. 200). Bickhard (p. 241) and Arnellos and El-Hani (p. 260/1) both take the candle flame and a bacterium swimming up a sugar gradient (p. 241/2 and 265) as examples of two important types of self-maintaining emergent phenomena, but neither makes any reference to the other.

Brute facts are one important sort of limit to scientific explanation. All chapters of the book are original contributions to research in metaphysics and philosophy of science. The issue of the limits of science is very important for science education, although the relevance of the issues raised by brute facts for science education is not explicitly mentioned in the book. One of the strengths of science is its apparent universality. The scientific method seems to have a very wide scope: indeed, it can be used to address all factual questions, and it seems to provide us with the best possible means to answer them all. However, the scope of what can be scientifically explained today is certainly limited in many ways. There are many questions that have no scientific answer because there are not purely factual, such as questions about good policy or good medical therapies. Other questions, though purely factual, have at present no scientific answer because, among other reasons, (1) our ability of observation and description of facts is limited, (2) our theories and models are incorrect or incomplete, or (3) because our application of these models and theories requires more time or calculating power than is available. Our theories or models may be incomplete or incorrect because we lack time or money for acquiring or constructing the relevant experimental equipment or for improving the models and theories, or simply because our cognitive abilities are limited. The existence of brute facts would constitute an altogether different sort of limit of the scope of science. Brute facts can contribute to explaining other facts, but they cannot themselves be explained. They could not even be explained if all the before mentioned limitations had or could be overcome.

The contributions to the book clearly show that the existence of such brute facts, whether fundamental or emergent, does not threaten the unique power of science to explain all other, i.e. non-brute facts, and that a clear acknowledgment of the existence of brute facts itself

enhances our understanding. The fact that some facts cannot be explained leaves untouched the status of science as uniquely rational method of inquiry.

A lucid evaluation of the limits of science is as important for science education as the analysis of what can be achieved by science. In order to defend the reliability of the scientific method against antiscientific challenges, it is important to reflect on the scope and limits of scientific explanation. By contributing to this task, the book will be useful and relevant as a background for science educators and science education research.

Compliance with Ethical Standards

Conflict of Interest The author declares no conflict of interest.

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