

Is There a Fundamental Level?

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“Thus I believe that there is no part of matter which is not—I do not say divisible—but actually divided; and consequently the least particle ought to be considered as a world full of an infinity of different creatures.” (Leibniz, letter to Foucher)

“O amazement of things—even the least particle!” (Walt Whitman, “Song at Sunset”)

1. Talk about “the fundamental level of reality” pervades contemporary metaphysics. The fundamentalist starts with (a) a hierarchical picture of nature as stratified into *levels*, adds (b) an assumption that there is a bottom level which is *fundamental*, and winds up, often enough, with (c) an ontological attitude according to which the entities of the fundamental level are *primarily* real, while any remaining contingent entities are at best derivative, if real at all. Thus the *physicalist* claims that microphysical theory (or some future extension thereof) describes the fundamental level of reality on which all else supervenes; the *Humean* claims that all supervenes on the distribution of local, fundamental qualities in spacetime; the *epiphenomenalist* claims that all causal powers inhere at the fundamental level; and the *atomist* claims that there are no macroentities at all but only fundamental entities in various arrangements.

I find the hierarchical picture of nature in (a) plausible as reflected in the structure and discoveries of the sciences, and consider the ontological primacy of the fundamental entities in (c) a natural (though not inevitable) conclusion. In any case I will not discuss these issues here. Rather I will discuss the assumption (b) that there exists a fundamental level; first because it is almost entirely neglected; second because, as I will argue, there is no evidence in its favor; and third because the hierarchical picture minus (b) yields a far more palatable metaphysic in which, *contra* (c), all entities are equally real.

So why believe that there *is* a fundamental level? Why not an infinite descending hierarchy of levels?

In discussing the evidence for fundamentality I will, on route, clarify the various senses of “levels”, assess the epistemic standing of various fundamentalist doctrines such as physicalism, and present a rival metaphysic of infinite descent which is at home in the macroworld.

2. The proposition that there is a fundamental level is widely accepted but seldom defended. To pick a salient example, Paul Oppenheim and Hilary Putnam, in their classic discussion of the unity of science, postulate without further defense: “There must be a unique lowest level . . .” which they label that of “Elementary Particles” (p. 409). Such fundamentalist assertions are best understood in the context of the overall fundamentalist picture, which Jaegwon Kim sketches:

The Cartesian model of a *bifurcated* world has been replaced by that of a *layered* world, a hierarchically stratified structure of “levels” or “orders” of entities and their characteristic properties. It is generally thought that there is a bottom level, one consisting of whatever microphysics is going to tell us are the most basic physical particles out of which all matter is composed (electrons, neutrons, quarks, or whatever). (1993, p. 337; see also Kim 2002, pp. 3–4)

Kim is careful to note that the idea that there is a bottom level is just an assumption of this picture (1993, p. 337). But this leads directly to the question: Why believe this assumption?

The picture Kim sketches traces back at least to Isaac Newton in the *Opticks* (1704), who hypothesizes that “the smallest particles of matter cohere” to “compose bigger particles”, which in turn compose still bigger particles, until the biggest particles “which by cohering compose bodies of a sensible magnitude” (p. 394). Newton’s picture of a world built out of fundamental particles survives in the rhetoric of contemporary textbooks such as C. D. Coughlan and J. E. Dodd’s *The Ideas of Particle Physics: An Introduction for Scientists*, whose preface proclaims: “We now have a convincing picture of the fundamental structure of observable matter . . .” And: “Matter, so it seems, consists of just two types of elementary particles: quarks and leptons. These are the fundamental building blocks of the material world . . .” (ix).

The Newtonian picture has not gone unchallenged. The alternative picture of infinite descent traces back at least to Newton’s great rival G. W. F. von Leibniz (see opening quote), and resurfaces in W. S. Jevons (1877):

Go on as far as we will, in the subdivision of continuous quantity, yet we never get down to the absolute point. Thus scientific method leads to the inevitable conception of an infinite series of successive orders of infinitely small quantities. (quoted in Rescher 1984, p. 50)

For physicist-*cum*-philosopher David Bohm, the idea of fundamentality is the last refuge of the discredited mechanistic worldview, to be superseded by “the qualitative infinity of nature”, which postulates an “inexhaustible *depth* in the properties and qualities of matter” (p. 138) which “is consistent with an infinity of levels” (p. 139).¹ The Leibnizian picture of infinite division survives in the speculations of Nobel laureate Hans Dehmelt, who postulates an infinite regression of sub-electron structure.

Fundamentality, then, requires defense, especially given such a well-articulated (and impressively pedigreed) alternative. What is the evidence for fundamentality?

3. “Levels” is a metaphor, which must be unwoven in order to assess the evidence for fundamentality.

The central connotation of the “levels” metaphor is that of (a) a *mereological structure*, ordered by the part-whole relation. This connotation is implicit both in Newton’s talk of “the smallest particles”, and in Coughlan and Dodd’s use of the cliché “fundamental building blocks”; and this connotation is explicit both in Oppenheim and Putnam’s use of part-whole relations to distinguish microtheory from macrotheory (p. 407), and in Kim’s presentation of the fundamentalist picture:

The ordering relation that generates the hierarchical structure is the mereological (part-whole) relation: entities belonging to a given level, except those at the very bottom, have an exhaustive decomposition, without remainder, into entities belonging to lower levels. (1998, p. 15)

So a fundamental level is a level of entities that have no proper parts: *atoms*, in the etymological sense.

The peripheral connotations of “levels” include those of (b) a *supervenience structure*, ordered by asymmetric dependencies; (c) a *realization structure*, ordered by functional relations; and (d) a *nomological structure*, ordered by one-way bridge principles between families of lawfully interrelated properties. Those who speak of levels typically suppose that most if not all of these connotations comport.² Thus William Lycan speaks of a “multiple hierarchy of levels of nature, each level marked by a nexus of nomic generalizations and supervenient on all those levels below it on the continuum” (p. 38). Of course these connotations can come apart, and if they do, or at least do to a significant enough degree, then perhaps the entire “levels” metaphor is best abandoned.

So the question of the evidence for fundamentality is best understood as the question: What is the evidence for mereological atoms? And here there is a presupposition that mereological atoms, if such exist, also comprise the ultimate supervenience base, the cast of the prime realizers, and the subjects of the fundamental laws of nature.

I will now discuss the evidence for the existence of mereological atoms. Later (§7) I will consider the possibility of a fundamental supervenience base without atoms, since some of the fundamentalist doctrines I will take issue with can get by with an atomless base.

4. What is the evidence that there are mereological atoms? Since the fundamentalist begins with the hierarchical picture of nature, which is an empirical thesis based on the idea that the structure and discoveries of science reflects the structure of nature, the thematic fundamentalist ought then to look to the structure of science for empirical evidence for a fundamental atomic structure in nature. Thus I think that there is only one serious argument for atomism, which is that *science indicates atomism*—the trajectory of current physics points to a world constituted out of simple microphysical particles. I will, however, briefly dismiss some *a priori* arguments for atomism first. (The reader already convinced that the *a posteriori* argument from current science is the only serious argument for atomism may skip to the next section.)

One might claim that atomism is *a priori* knowable because it can be seen to be metaphysically necessary. (Andrew Pyle maintains that the Greek Atomists held this position, due to pre-Cantorian difficulties with infinity.) I reply that the Leibnizian picture of infinite division passes excellent tests for being possible: it is (a) *conceivable*, (b) *logically consistent*, and (c) *physically serious*. As to conceivability, it is conceivable that everything has parts. That is, it is conceivable that everything is extended, and that everything that is extended can be divided. It is conceivable that everything is molecular (Ted Sider 1993, p. 288 and 1995; David Armstrong 1997, p. 33). As to logical consistency, there are known models for atomless mereologies, such as that of the regular open sets of a Euclidean space, with parthood taken as set-inclusion for these sets (Peter Simons 1987, p. 41; David Lewis 1991, p. 20 labels such atomless entities “gunk”). As to physical seriousness, I have already given examples in §2 (and will offer more in §5) of serious physical hypotheses involving infinite division (see also Block forthcoming). This leads to the question of the empirical standing of these physical hypotheses, which leads back to the question of whether science is actually in the process of discovering atoms.

One might claim that atomism is not *a priori* knowable, but still *a priori* methodologically preferable, since it is a more economical supposition than infinite division. I reply that (a) there are *competing methodological considerations* that favor infinite division, and (b) economical preferences cannot bear so much metaphysical weight. As to the competing methodological considerations, infinite division allows greater *explanatory scope* in that the workings of every single entity is explicable in terms of the workings of its parts,³ and infinite division yields a more *elegant hypothesis* in that the

pattern of division embraces the whole structure of nature. As to bearing weight, even if atomism were to prove on balance economically preferable, such a claim would be counterbalanced by any counterintuitive consequences (such as epiphenomenalism). That is to say, in effect, that there is a further methodological consideration of *conservatism* that would now press the scales with a force proportionate to the counterintuitiveness of the consequences. So if fundamentality is to have bite, it must be an empirical *discovery*, rather than a mere methodological *presumption*. And this leads back to the question of whether science is actually in the process of discovering atoms.

One might, finally, regard infinite division with a blank stare, as neither impossible nor methodologically suspect, but as intuitively bizarre and thus *a priori* implausible. I reply that such a blank stare evidences brainwashing: (a) infinite division is if anything the *more natural* doctrine, and (b) *subtleties of topology* show that the folk may actually be committed to atomless gunk. As to naturalness, a body of water looks as if it is an undifferentiated continuum. Engineers successfully apply continuum mechanics to a wide range of “normal” situations.⁴ Wilfrid Sellars claims that in the manifest image the pink ice cube is a continuously pink solid all the way down, so that to the extent the scientific image postulates a grainy underlying material structure, the manifest and scientific images are in tension. As to subtleties of topology, Dean Zimmerman argues that if there are extended material objects that can literally touch, they can do so only at gunky junctures. If so then any descriptive metaphysics is committed to infinite division. I suggest that it is only because we have become so inured to this particle-based scientific image that we have inherited from Newton, that atomism may now *seem* so plausible. But this leads back once again to the question of whether science indeed indicates atomism.

I conclude that the real question is the empirical question of whether science indicates atomism. The existence, structure, and number of the levels of nature cannot be intuited from the armchair.

5. Does science indicate atomism? Does the trajectory of current physics point to a world constituted out of simple particles? Coughlan and Dodd are arguing this way when they assert: “We now have a convincing picture of the fundamental structure of observable matter in terms of certain point-like elementary particles” (p. ix). Kim speaks of “whatever our best physics is going to tell us are the basic bits of matter out of which all material things are composed” (1998, p. 15). This *a posteriori* argument for atomism may be formulated as:

- (1) There will be a complete microphysics,⁵
- (2) The complete microphysics will postulate particles, and
- (3) These particles are the mereological atoms.

I reply that the empirical evidence does not favor *any* of (1)–(3).

Starting with claim (1), will there be a complete microphysics? Nobel laureate Steven Weinberg speculates *yes*:

If history is any guide at all, it seems to me to suggest that there is a final theory. In this century we have seen a convergence of the arrows of explanation, like the convergence of meridians towards the North Pole. Our deepest principles, although not yet final, have become steadily more simple and economical. (pp. 231–232)

Weinberg’s speculation is echoed by many philosophers, such as Kim (quoted above) and Lewis:

[W]e may reasonably think that present-day physics already goes a long way toward a complete and correct inventory [of the fundamental properties and relations that occur in the world]. Remember that the physical nature of ordinary matter under mild conditions is very well understood. And we may reasonably hope that future physics can finish the job in the same distinctive style. (1999, p. 292)

I reply that the history of science is littered with such speculations. To pick a particularly ill-timed example, the physicist Albert Michelson declared in 1894: “[I]t seems probable that most of the grand underlying principles have been firmly established and that further advances are to be sought chiefly in the vigorous application of these principles . . .” (p. 15). To pick a particularly brazen example, Max Born declared in 1928 (after seeing the Dirac equation) that “physics, as we know it, will be over in six months” (quoted in Hawking, p. 119). And to pick a more recent example, Stephen Hawking, in his 1979 Lucasian Lecture, predicted that theoretical physics would be complete “by the end of the century” on the basis of $N = 8$ supergravity, a theory which is now defunct.

Indeed, the history of science is a history of finding ever-deeper structure. We have gone from “the elements” to “the atoms” (etymology is revealing), to the subatomic electrons, protons, and neutrons, to the zoo of “elementary particles”, to thinking that the hadrons are built out of quarks, and now we are sometimes promised that these entities are really strings, while some hypothesize that the quarks are built out of preons (in order to explain why quarks come in families). Should one not expect the future to be like the past?⁶

Perhaps this stage of history is special? I think this almost impossible to prejudge. As long as current microphysics remains unfinished, it is nearly impossible to foresee which difficulties will yield to tinkering, and which will require radical revisions. How, for instance, could Michelson have foreseen that the problem of the perihelion of Mercury would require a relativistic

reconception of spacetime?⁷ And when the next scientific revolution rolls in, who can say how far away our current perspective may then seem?⁸

David Lindley identifies these prophecies of “the end is near!” with “the messianic movement in fundamental science” (p. 206). I think these prophecies express a useful myth. (Anyone who has worked on a dissertation will understand the psychology.) The physicist who can convince herself and others that her research project is on the verge of completion will no doubt work harder and receive more funding. But it is a mistake to take such wishful thinking and politicking as a guide to ontology. This is not part of the serious business of science.

Further evidence that this is at best a useful myth for the practicing physicist comes from the fact that those who predict a complete microphysics do not even agree on its content. Thus Coughlan and Dodd bet on the Standard Model and remain deeply skeptical of strings, Weinberg bets on superstring theory, and Gordon Kane, who identifies as a supersymmetry theorist, bets that Witten’s M-theory lies behind string theory, and that behind M-theory lies “the primary theory” whose content is entirely unspecified save that it “includes a derivation of space-time, and the meaning and number of dimensions, explains why quantum theory and relativistic invariance are the rules of nature, where the laws of physics come from, and why M-theory is the unique theory describing our world” (p. 135). This is more a wish list than a prediction.

So with regard to whether there will be a complete microphysics I council agnosticism. The issue here is not the *progressivist* thesis that microphysics has grown deeper and more accurate. That thesis I emphatically accept. The issue is the *perfectionist* thesis that the depths shall be plumbed and the margin of inaccuracy shall vanish. Why think microphysical progress must form a finitely converging sequence?⁹ Why not progress *forever*? My own view is best captured by Murray Gell-Mann’s response to John Horgan’s question of whether science is finite or infinite: “That’s a very difficult question. I can’t say.” (quoted in Horgan, p. 215).

Of course if one is *assuming* atomism from the start, I can see why one would expect perfection once one had a theory couched at the level of the atoms. But the question is, why assume atomism? Here the dogma is chasing its tail.

Turning to claim (2), will the complete microphysics (if such there be) postulate particles? I reply that *we simply do not know until we know what the theory actually says*. In the most favorable case the theory may postulate point entities such as Daltonian atoms. In the intermediate case, the theory may postulate spatially extended entities such as strings, so raising at least the specter of spatial parthood. In the least favorable case, the theory may explicitly postulate infinitely divisible entities such as in a pure field theory.

The claim that a complete microphysics must be a theory of particles, much less of discrete entities at all, is just an article of faith. The introduction

of quantum field theory should serve as a cautionary tale here,¹⁰ as Weinberg makes clear:

From [the replacement of quantum electrodynamics by quantum field theory] we may draw the moral that it is foolhardy to assume that one even knows the terms in which a future final theory will be formulated. Richard Feynman once complained that journalists ask about future theories in terms of *the ultimate particle of matter* or the final unification of all the forces, although in fact we have no idea whether these are the right questions. (p. 172, italics added)

Indeed, considerations of renormalization in quantum field theory have led physicist Howard Georgi to suggest that effective quantum field theories might form an infinite tower which “goes down to arbitrary short distances in a kind of infinite regression . . . just a series of layers without end” (p. 456).¹¹

So with regard to whether the complete microphysics (if such there be) will postulate particles, I once again counsel agnosticism. Of course if one is assuming atomism again, I can see why one would expect particles in the final theory. But here the dogma is just chasing its tail again.

In any case, even if we do discover a complete, particle-based microphysics, I say that even then it does not follow that these particles are mereological atoms as per (3). In general, it seems that any entities might or might not have parts. Why are the particles postulated by a complete microphysics any less amenable to division than any other entities?¹²

That the particles are postulated by a complete microphysics shows only that one can tell a complete causal story with particles as protagonists. But one can tell a complete causal story with divisible protagonists, provided that the divisions are *boring*, in that the characteristic properties of all the parts supervene on the characteristic properties of their wholes. Blaise Pascal, for instance, believed that each part of matter housed a micro-universe with a miniature earth, sun, and planets, and that each part of matter of this micro-verse housed a micro-microverse, *ad infinitum*. On Pascal’s worlds-within-worlds picture there is of course no fundamental level of nature, but there presumably could be a complete physical theory applicable at every level, as long as the same dynamics applies throughout.

So I conclude that we do not, right now, have any evidence for atomism. We now have no evidence that there will be a final theory, no evidence that such a theory will postulate anything that could serve as a mereological atom, and no evidence that such a theoretical postulate will correspond to an ontological atom as opposed to a boringly decomposable composite. Evidence for fundamentality is lacking thrice over.

In short, there are at least two perfectly good conceptions of the hierarchy of nature: fundamentality and infinite descent. The empirical evidence to date is neutral as to which structure science is reflecting. And

so, concerning the proposition that there exists a fundamental level of nature, one should withhold belief.

6. I anticipate three main lines of retreat. First, it might be claimed that certain fundamentalist doctrines, such as physicalism, can be (re)formulated without presupposing fundamentality. Second, it might be thought that, even though there is no evidence for mereological atoms, there may still be evidence for a fundamental something else, such as a fundamental supervenience base. Third, it may be maintained that fundamentality still remains an important metaphysical perspective as a live possibility.

Starting with the first line of retreat, can certain fundamentalist doctrines be (re)formulated without presupposing the existence of a fundamental level? I will consider physicalism, Humeanism, epiphenomenalism, and atomism in turn, and show that all presuppose fundamentality in some sense.

Starting with physicalism, this doctrine has received various formulations, which turn out to correspond to the various mereological, supervenience, realization, and nomological connotations of “levels”. Thus Phillip Pettit defines physicalism as the conjunction of the mereological claim that micro-entities exist and compose all else, and the nomological claim that microlaws exist and govern all else. Jeffrey Poland associates physicalism with the realization thesis that, for all possible nonphysical attributes and objects, there exists a minimal realizing class of physical attributes or physical objects respectively.¹³ And Frank Jackson, in perhaps the most influential formulation to date, defines physicalism as the supervenience thesis that “Any world which is a minimal physical duplicate of our world is a duplicate *simpliciter* of our world” (p. 160). All of these formulations can be seen as expressions of the core physicalist idea that the world is, in some sense, nothing over and above the physical, and that the mental in particular is a derivative feature of reality.¹⁴

In an infinite descent, the problem for the physicalist is to identify “the physical base”. Here the physicalist faces a dilemma concerning whether the physical base is found at some finite number of levels, or found at the infinitely many levels below a certain cut-off. On the first horn of the dilemma, if the physical base is found at some finite number of levels then physicalism will turn out false. Given the suppositions of (a) infinite descent, and (b) that the mereological, supervenience, realization, and nomological structures comport (in the next section I will consider the line of retreat in which this supposition is waived), it follows from (a) that for any finite set of entities included in the physical base, there will be lower level entities left out, and then it follows from (b) that these lower level entities will fail to be composed of, supervenient upon, realized by, and governed by, the physical base. So there would be, in every sense, more to the world than the physical.

On the second horn of the dilemma, if the physical base is found at the infinitely many levels below a certain cut-off then physicalism will turn out toothless.¹⁵ Given the suppositions of (a) infinite descent, and (b) compartment last paragraph, it follows that any infinite base must be infinitely redundant. Consider the cut-off level L. It can be deleted from the base, because by (a) there is a level L-1 below it which is also in the base, and by (b) all the entities at L are composed of, supervenient upon, realized by, and governed by, L-1. Now by parity of reasoning L-1 can be deleted because of L-2, L-2 can be deleted because of L-3, *ad infinitum*. The consequence of this is that *it is entirely arbitrary where to draw the cut-off* (and labeling one cut-off “the physical” won’t change that). Any choice of L will form a true-but-redundant base. It may be true-but-redundant that everything is (in some sense) nothing over and above the subatomic and below, but it will also be true-but-redundant that everything is nothing over and above the chemical and below, and equally true-but-redundant that everything is nothing over and above the psychological and below. No ontologically interesting difference between quarks and qualia would remain.

In an infinite descent there is nothing ontologically interesting about the divide between the chemical and the atomic levels, or between any two levels. Physicalism is an irreparably fundamentalist doctrine because it requires an ontologically motivated distinction between a primary physical base, and that which, like the mental, is derivative. The fundamental level provided such a distinction, by introducing a discontinuity in nature where the pattern of division was broken. Without a fundamental level there is no *joint* in the descending hierarchy to put the line between the primary and the derivative.¹⁶

Turning to Humeanism, this doctrine, as formulated by its leading proponent David Lewis, is explicitly a supervenience doctrine:

Humean Supervenience...says that in a world like ours the fundamental relations are exactly the spatiotemporal relations.... And it says that in a world like ours the fundamental properties are local properties.... Therefore it says that all else supervenes on the spatiotemporal arrangement of local qualities throughout all of history... (1999, pp. 225–226)

Lewis also explains Humeanism in terms of the metaphors of tiles of a mosaic (1986a, p. ix), and of pixels of a picture (1999, p. 294), which suggests an implicit mereological aspect to his view: “a supervenience of the large upon the small and many” (1999, p. 294).

In an infinite descent the problem for the Humean is to identify “the Humean base”. Lewis’ specification involving fundamental local properties becomes doubly problematic. First, assuming that a mereological part is a spatiotemporal part (the spatiotemporal embodiment of mereological relations), then there will be no local qualities, but rather an infinite sequence of ever-smaller instantiations. Second, and I think even more seriously, Lewis’

definition of the fundamental properties and relations as the minimum required “to characterize things completely and without redundancy” (1986b, p. 60) will fail to pick out anything (assuming again that the mereological and supervenience relations comport). No finite set of properties and relations will characterize anything completely because of the inexhaustible depth of nature, and no infinite set will characterize anything nonminimally because those belonging to the topmost level can always be deleted. This is in fact the same dilemma as besets physicalism in an infinite descent. *The very idea that there exists a minimal base is a fundamentalist presupposition.*¹⁷

Lewis at times labels the existence of fundamental properties and relations as necessary *a priori* (1999, p. 225, p. 291). Yet, commenting on a passage of David Armstrong’s defending the possibility of infinite descent, Lewis concedes that denial of such would be “objectionably high-handed, if not downright intolerable” (1999, p. 86). Lewis (personal communication) takes the view that infinite descent, while admittedly possible, remains a distant enough possibility to fall beyond the scope of Humean supervenience (a contingent hypothesis). Perhaps so. But how distant a possibility is depends on how the actual world is. If the actual world has a fundamental level, the possibility of infinite descent would presumably be very distant (involving additional *alien properties* below). But if the actual world is an infinite descent world, then the possibility of infinite descent would be as close as close can get. So Lewis’s reply leads to the question: What evidence shows infinite descent to be so distant? Which leads directly to the question: What evidence shows the actual world to have a fundamental level?

Turning next to epiphenomenalism, this doctrine has received various formulations, which (much like the various formulations of physicalism) correspond to the various mereological, supervenience, realization, and nomological connotations of “levels”. Thus Trenton Merricks derives epiphenomenalism from the mereological claim that the atoms do all the causal work, Kim (1993), Jerry Fodor, and Steven Yablo, *inter alia*, worry that the properties of the supervenience base do all the work, and Ned Block and Kim (1998) worry that the first-order realizers do all the work. The characteristic epiphenomenalist argument may be formulated as:

- (1) *Distinctness*: the higher level entities are distinct from their lower level compositors/subveners/realizers/governors.
- (2) *Micropower*: the lower level entities are causally potent.
- (3) *Exclusion*: it is not the case that both the higher and lower level entities are causally potent.
- (4) \therefore *Epiphenomenalism*: the higher levels entities are causally impotent.¹⁸

In an infinite descent, the problem for the epiphenomenalist is to locate the causal powers. Supposing that the causal powers are somewhere, at

some level L, it follows from the hypothesis of infinite descent that there are levels below L, and it follows from the premise of micropower (2) that the entities of these lower levels are causally potent—there will always be a lower level to drain the powers from L. So the causal powers cannot be at L after all. In this way every level will get excluded as a locus for the powers. So the epiphenomenalist cannot sustain the exclusion premise (3), or else (to borrow a metaphor from Kim 1998) all the causal powers would drain away down a bottomless pit.¹⁹

Turning finally to atomism, this doctrine is the explicitly mereological doctrine that there are no composite macroentities at all but only fundamental entities in various arrangements. As Merricks puts it, “Your visual experience is no hallucination; but it is caused by *atoms arranged statuewise*, not a statue” (2000, p. 47). Atomism, perhaps most obviously of all the fundamentalist doctrines, presupposes the existence of a fundamental level. In an infinite descent all entities are composite macroentities. In an infinite descent then, atomism would have the absurd consequence that all entities would dissolve into thin air.²⁰

Peter van Inwagen, who has developed a detailed quasi-atomist metaphysics on which there are no macroentities except for biological organisms, explicitly identifies atomism as one of the ten “convictions” which are “unargued-for presuppositions” of his view: “I assume . . . that matter is ultimately particulate. I assume that every material thing is composed of things that have no proper parts: ‘elementary particles’ or ‘mereological atoms’ or ‘metaphysical simples’” (p. 5). But this dubious physical hypothesis has no business amongst van Inwagen’s other more plausible assumptions, such as that identity is absolute, that there is an objective reality, and that you and I are material objects therein.²¹

So, given that one should withhold belief concerning fundamentality, one should in turn withhold belief concerning physicalism, Humeanism, epiphenomenalism, and atomism.

7. As a second line of retreat, the fundamentalist might maintain that, while there is no evidence for mereological atoms, there may yet be evidence for a fundamental something else. I think that there is one particularly interesting form of this retreat, on which this “something else” is a fundamental supervenience base. In any case I will limit my discussion of this retreat to this particular maneuver.

The disassociation between the mereological and supervenience hierarchies involved in this maneuver violates the fundamentalist presupposition that these connotations of “levels” comport. Nevertheless the view is perfectly consistent (although I know of no one who has explicitly advocated it, except in the apocryphal story about “turtles all the way down . . .”). There can be a supervenience base at a nonatomic level if there is a point in the mereological hierarchy below which all remaining mereological divisions are

boring (§5), as per Pascal's worlds-within-worlds hypothesis, and as expressed by the rhyme:

Great fleas have little fleas
 Upon their backs to bite 'em;
 Little fleas have lesser fleas,
 And so *ad infinitum*. (quoted in Bohm, p. 139)²²

So on this second line of retreat, the fundamentalist view cedes to the disjunctive view of there being either a fundamental level of nature or an infinitely boring descent. Call this *supervenience-only fundamentality*.

What is interesting about supervenience-only fundamentality is that, evidentially speaking, it is better off than full-blown fundamentality, and metaphysically speaking, more palatable. Evidentially speaking, supervenience-only fundamentality requires an analogue of the *a posteriori* argument for atomism rejected above:

- (4) There will be a complete microphysics,
- (5) The complete microphysics will describe a comprehensive supervenience base, and
- (6) Such a development will license an inference to supervenience-only fundamentality.

Lewis explicitly argues in this manner, when he speaks of future physics finishing the job of providing "an inventory of all the fundamental properties and relations that occur in the world" (1999, p. 292), which would establish "supervenience of everything upon the pattern of coinstantiation of fundamental *physical* properties and relations" (1999, p. 293).

Now I have already shown that there is no evidence for (4), and this suffices to show that there is no evidence for supervenience-only fundamentality. But what makes supervenience-only fundamentality evidentially better off than full-blown fundamentality is that (5) and (6) are in better epistemic shape than their respective analogues (2) and (3) in the argument for atoms.

While premise (2) of the argument for atoms required the unwarranted assumption that the complete microphysics will be a particle-based theory, (5) is correctly neutral as to the content of such a theory, and would apply equally to a pure field theory. Rather (5) expresses the plausible principle of *microdetectability*. To say that the microphysics is complete is to say that it tells a closed and comprehensive causal story: the objective prior probabilities of every microphysical event are fixed by antecedent microphysical conditions.²³ If such a complete theory failed to describe a comprehensive base, then there must be empirically possible differences nonsupervenient on

the microphysical. By their nonsupervenience these differences can make no difference to the microphysical conditions. By the completeness of the microphysics, these differences can have no impact on the microphysical probabilities. So these differences must be perfectly insulated from the microphysical.

What makes such perfect insulation implausible is that it seems, on both methodological and inductive-empirical grounds, that one should expect to be able to build a detector for any property (or at least any scientifically respectable property) which will “tip off” the microphysics. That is to say that it is methodologically and inductively plausible that, if entities X and Y differ in property, then there will be a possible *detector* for this difference that (i) can detect whether X or Y is present, and (ii) can impact the microphysical probabilities (such as concern the position of a pointer, for instance) on this basis. It follows that if a theory is complete there cannot be nonsupervening differences, or else the theory would turn out to be incomplete with respect to the output of the detector.²⁴

So a complete microphysics may plausibly be regarded as describing a comprehensive supervenience base, and this, as per (6), would license an inference to supervenience-only fundamentality. While (3) in the argument for atoms failed to exclude the possibility that the particles had boring parts, (6) is not defeated by this possibility since boring parts by definition supervene on their wholes.

Supervenience-only fundamentality is not only evidentially better off than full-blown fundamentality, it is also metaphysically more palatable, because it pulls physicalism and Humeanism apart from epiphenomenalism and atomism, which are to my mind far more obnoxious. For the physicalist and Humean could advert to the supervenience base for an ontological joint at which to divide the primary from the derivative. For the Jackson-style physicalist, for instance, a minimal base-duplicate of our world would indeed be a duplicate *simpliciter* of our world, since duplicating the base would fix not only all higher levels but also whatever lower levels there may be. For the Lewis-style Humean, the properties and relations of the base would provide a well-defined (albeit perhaps still nonlocal) class of properties and relations to characterize reality completely and nonredundantly. But the epiphenomenalist could not advert to the base as the locus for the powers because supervenience-only fundamentality explicitly leaves open the possibility of infinitely boring descent, in which the supervenience relations go symmetric: the boring parts and their wholes each supervene on the other (mereological relations, in contrast, are necessarily asymmetric). But this renders epiphenomenalism incoherent, because each base would exclude the other from being the location of the powers. And the atomist of course could not advert to supervenience-only fundamentality because the entities of the base are now explicitly allowed to be mereologically composite.

Indeed, the discovery of a comprehensive supervenience base, atoms or not, would in every important sense constitute “the end of science”. No reason why science should have to end in particles. The base would give us all we could ever need for prediction and control (everything depends on it). There might be more science that could be done in terms of mapping out lower level mereological structures, but there would be nothing unpredictable to be found, and hence no theoretical revolutions to be wrought.

So it is in fact worth distinguishing (at least) three metaphysical pictures: full-blown fundamentality, supervenience-only fundamentality, and full-blown infinite descent. Should we not discover a complete microphysics (or should we at least continue to discover ever-deeper novel structure) this would provide evidence for infinite descent. Should we discover a complete microphysics, this would then provide evidence for supervenience-only fundamentality, and allow for physicalism and Humeanism. Should the complete microphysics also turn out to postulate particles, and should these particles turn out indivisible, this would then provide evidence for full-blown fundamentality, and allow for epiphenomenalism and atomism in addition. For now, all of these outcomes must be regarded as live possibilities.

8. As a third and final line of retreat, the fundamentalist might claim that fundamentalism is a live possibility and as such remains an important philosophical issue. Pettit recommends this attitude towards physicalism:

Many philosophical projects attempt to vindicate commonsense discourses.... It is good practice with such projects to try to vindicate the target discourse under hard assumptions rather than easy ones.... [T]he assumptions associated with physicalism... represent a worst-case—or at least a pretty bad-case—scenario from the point of view of relevant, discourse-saving projects. The fact that the physicalist picture is a scenario of this kind does not give philosophers reason to believe it, of course, but it may give them reason to carry on as if it were sound; it may give them reason to treat physicalism as a standard, working hypothesis. (pp. 221–222)

I reply that Pettit is partly right, but that it would be even better practice to have one’s discourse open to *all* the live possibilities, and to beware that adopting only one working hypothesis can lead to a distorted perspective. In fact, given how pervasive fundamentalism is in contemporary metaphysics, there is at least as much reason to treat infinite descent as a working hypothesis.

What would a metaphysic of infinite descent look like? The most striking feature of an infinite descent is that *no level is special*.²⁵ Infinite descent yields an egalitarian ontological attitude which is at home in the macro-world precisely because everything is macro. Mesons, molecules, minds, and

mountains are in every sense ontologically equal. Because there can be no privileged locus for the causal powers, and because they must be somewhere, they are everywhere. So infinite descent yields an egalitarian metaphysics which dignifies and empowers the whole of nature.

Treat infinite descent as a working hypothesis, and since all entities turn out to be composite, supervenient, realized, and governed, it emerges that these attributes cannot be barriers to full citizenship in the republic of being.

The macroworld, once regained, is not easily lost, even should real evidence for fundamentality arrive. Here I am, a human organism, a macro-entity, but in no sense unreal for that. I believe that I am both composed of and dependent on certain cells, which are in turn both composed of and dependent on certain molecules, which are in turn both composed of and dependent on certain atoms, which are in turn both composed of and dependent on certain subatomic particles, which are in turn both composed of and dependent on certain quarks and leptons. We just don't know whether this chain stops. But from this perspective it seems obvious that my realness does not in any sense turn on whether there are preons and so on below, or not.

To see that there is no evidence for fundamentality is already to regain the macroworld.²⁶

Notes

¹ Bohm is explicit that his view is also consistent both with finitely many levels, and with the possibility that the very notion of "levels" may be superseded. These are, he recognizes, purely empirical matters. For more on Bohm's view see his pp. 132–140.

² Some exceptions: Kim now thinks that the idea that the realization and supervenience orders track the mereological levels is mistaken, since: "a second-order property and its realizers are at the same level in the micro-macro hierarchy; they are properties of the very same objects." And: "supervenient properties and their base properties are instantiated by the same objects and hence are on the same level" (1998, pp. 82–3). Nancy Cartwright proposes a "dappled world" glued together by irreducible single-case causal relations for which a plurality of law hypothesis may at best provide useful idealizations (/lies). Her proposal challenges the idea of fundamental nomological structure, but is neutral with respect to mereological structure. And William Wimsatt proposes a mereo-*mechanistic* hierarchy of whole systems and component parts, with explanatory and supervenience relations swirling in both directions (especially in the 'bio-psychological thicket' of levels), due to the context-sensitive behavior of most components. His proposal challenges the idea that the supervenience structure tracks the mereological structure, and represents an attempt to free the mereological hierarchy from an ontological bias for parts over wholes (thus challenging (c) of §1).

³ According to Karl Popper, "There can be no explanation which is not in need of a further explanation . . ." (p. 195).

⁴ See, for instance, W. Michael Lai, David Rubin, and Erhard Kremppl's *Introduction to Continuum Mechanics*: "The continuum theory regards matter as indefinitely divisible" (p. 1).

⁵ Actually claim (1) is stronger than need be. What is really required is reason to believe that microphysics can, in principle, achieve a point where, if any gaps remain in the causal story it postulates, they won't be the kind of gaps that postulation of still smaller entities might fill.

(A complete microphysics is just the case of an actual and gapless causal story.) So microphysics might remain in practice incomplete due to historical misfortune or human limitation, or in principle incomplete due to computational (Gödel-style) incompleteness or due to the world having an anarchic aspect, without necessarily impinging on the argument for atoms, as long as we have evidence that any failures of completion are for *one of those* kind of reasons. The reader should beware that there is an extensive literature on the issue of “the end of science” (including Gunther Stent 1969, Bentley Glass 1971, and John Horgan 1996) in which these scenarios are not always separated (Nicholas Rescher 1984 being a notable exception).

⁶String theorist Brian Greene, in *The Elegant Universe*, adroitly addresses the question of “What are strings made of?” He allows two possible answers: “First, strings are truly fundamental—they are ‘atoms’, *uncuttable constituents*, in the truest sense of the ancient Greeks.” And then:

[H]istory surely has taught us that every time our understanding of the universe deepens, we find yet smaller microconstituents constituting a finer level of matter. And so another possibility . . . is that [strings] are one more layer in the cosmic onion. . . . String theorists have raised and continue to pursue this possibility. To date there are intriguing hints in theoretical studies that strings may have further substructure, but there is as of yet no definitive evidence. Only time and intensive research will supply the final word on this question. (pp. 141–142)

⁷Actually Michelson’s misplaced optimism is particularly striking since he is the very Michelson, who, together with Michael Morley some seven years *earlier*, had produced experimental results in conflict with the reigning aether hypotheses.

⁸Weinberg dismisses these previous speculations as the products of mere complacency in the face of deep problems. But no doubt Michelson, Born, and Hawking did not see themselves as complacent. And no doubt Weinberg does not see himself as complacent either, though it is all too easy to imagine Weinberg being quoted one hundred years and one or two scientific revolutions from now as yet another complacent optimist, who simply lacked the terms to see how far away he and his cohorts were from understanding, say, how to reconcile quantum mechanics and gravitation.

⁹W. V. O. Quine has criticized the very idea of convergence on a final theory, since: “the notion of limit depends on that of ‘nearer than’ which is defined for numbers and not for theories” (p. 23).

¹⁰There is an ongoing dispute concerning whether quantum field theory can be given a particle interpretation. As Paul Teller points out, the particle interpretation faces the formidable problem of saying what is going on when the number operator takes non-whole-number values.

¹¹Tian Yu Cao and Silvan Schweber embrace the infinite tower picture, suggesting that there is new effective physics every time one moves to a sufficiently smaller scale. Georgi himself concludes that an infinite tower of effective quantum field theories is unlikely, not so much for fundamentalist reasons, but rather because he expects quantum field theory itself to break down below the Planck scale, and cautions against guessing the structure of physics below the Planck scale until we understand how to reconcile quantum mechanics with gravitation. Nick Huggett and Robert Weingard council agnosticism.

¹²In fact, when quarks were first proposed the main rationale was not any incompleteness in the menagerie of elementary particles (of which hundreds had been identified), but rather to account for the fact that all the hadrons could be classified by “the eightfold way”. So here is an actual example of a complete (or at least thought then to be complete, prior to the scattering experiments at Stanford), particle-based microphysics whose entities were taken to be fully amenable to division.

¹³This is, in essence, Poland’s (T1a)-(T1c). Poland also adds theses about how the physical base fixes the facts, the truth, regularities, and explanation (his T2-T5). See pp. 186–224 for Poland’s full view.

¹⁴ Tim Crane and Hugh Mellor have challenged whether there is any defensible, nonvacuous physicalist thesis. I shall here be content to put my point as the conditional objection that *if* there is a defensible, nonvacuous physicalist thesis, it will still have the dubious empirical presupposition of fundamentality.

¹⁵ Pettit defines the physical base as “a realm of smaller and simpler microphysical entities” (p. 214) because he explicitly (and laudably) wishes to “leave open, as some physicists wish to do, even the question of whether there is any bottom level of smallest or simplest grain” (214–5).

¹⁶ Some of the physicalist spirit can survive. The physicalist insistence, for instance, that the mental is somehow based in the neurochemical survives, even though no contrast class of basic entities remains. I should perhaps say that, of the four fundamentalist doctrines here discussed, more of physicalism can survive than of the others.

¹⁷ There are weaker Humean theses that do not presuppose fundamentality. Lewis’ view can be parsed into three chained supervenience theses: (L1) The modal facts supervene on the nomic and occurrent facts, (L2) The nomic facts supervene on the occurrent facts, and (L3) The occurrent facts supervene on the fundamental occurrent properties and relations. One can agree with Lewis on (L1) and (L2) (as I myself am wont to do), while questioning (L3). Humeanism minus (L3) is not only compatible with infinite descent, but it also avoids conflict with quantum nonlocality.

¹⁸ There are other concerns specific to the potency of the *mental*, such as those stemming from Donald Davidson’s anomalous monism, and those stemming from Tyler Burge’s content externalism, that are independent of the general macro-epiphenomenalism discussed here.

¹⁹ Ned Block raises an essentially similar worry: “But what if there is no such [fundamental] level? This is a real physical possibility. . . [Jackson and Pettit’s] position dictates that we do not now know for sure whether there are any causally efficacious properties at all” (1990, p. 168). See also Block forthcoming for a more detailed rendering of this argument.

²⁰ R. W. Sperry, apparently assuming an infinite descent, raises this very objection: “The reductionist approach that would always explain the whole in terms of the parts leads to an infinite regress in which eventually everything is held to be explainable in terms of essentially nothing” (1976, p. 167).

²¹ Sider 1993 offers a related line of criticism.

²² There are some partial physical examples of boring division. For instance, if the whole has the property of *being a proton*, then this fixes the parts at 2 up-quarks and 1 down-quark. (This is only partial because, once we move to Quantum Chromodynamics, the color of the quarks and the color and number of the gluons can vary so long as the proton is net colorless.)

²³ Here I am drawing on Barry Loewer 1995.

²⁴ This microdetectability principle is a generalization of the principle of the microdetectability of the mental, which David Papineau (1995) as well as Barry Loewer (1995) use to argue for the supervenience of mental on physical.

²⁵ One of the levels might still have the special status of being the top level. But, unlike bottomness, topness does not seem to carry ontological significance.

²⁶ Thanks first of all to Ernest Sosa, who started me thinking about this topic. Thanks also to Craig Callender, Chang-Seong Hong, Ned Markosian, and Andrew Melnyk, who commented on various presentations of this material, as well as to David Armstrong, David Lewis, George Musser, and the *Noûs* referees for helpful feedback.

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