Humean Supervenience?

Microphysicalists hold that microphysics provides a subvenient basis upon which all else supervenes: fix the microphysical properties of a world like ours, and one fixes all the properties of a world like ours. I would like to endorse this thesis of microphysical supervenience.

David Lewis has defended the philosophical tenability of a different thesis, the principle of Humean Supervenience, according to which the spatiotemporal arrangement of local qualities provides an irredundant subvenient basis upon which all else supervenes. Under the natural assumption that the fundamental point properties on which all else supervenes are microphysical, the doctrine of Humean supervenience entails that the spatiotemporal arrangement of local microphysical qualities provides an irredundant subvenient basis upon which all else supervenes. I do not want to accept this natural consequence of the principle of Humean Supervenience. Moreover, I do not think that microphysicalists should look with too much fondness on Lewis' defence of the philosophical tenability of the principle of Humean Supervenience. The best reasons for looking askance at the principle of Humean Supervenience are also good reasons for thinking that the principle may not be 'philosophically tenable'—or so I shall argue.

The plan of the paper is as follows. I begin, in section I, by rehearsing Lewis' formulation of the principle of Humean Supervenience, and provide a brief discussion of some objections to it which he considers and sets aside. In sections II and III, I discuss some further objections to the principle of Humean Supervenience, including some which I wish to endorse. As far as I

know, these objections are novel—i.e. they have not hitherto been discussed in the literature. In section IV, I take up the question of the bearing of the objections which I endorse on the claim that the principle of Humean Supervenience is 'philosophically tenable'. Finally, in section V, I close with some considerations about the proper characterisation of the doctrine of microphysicalism.

I

Lewis (1994) formulates the principle of Humean Supervenience thus:

> In a world like ours, the fundamental relations are exactly the spatiotemporal relations: distance relations, both space-like and time-like, and perhaps also occupancy relations between point-sized things and space-time points. In a world like ours, the fundamental properties are local properties: perfectly natural intrinsic properties of points, or of point-sized occupants of points. All else supervenes on the spatiotemporal arrangement of local qualities throughout all of history, past and present and future. (p.474)

He then notes four apparent problems for Humean Supervenience, none of which he supposes to be unanswerable, viz: (i) it is at least *prima facie* doubtful that vector fields are arrangements of local qualities; (ii) it is doubtful that 'worlds like ours' are merely 'worlds of the inner sphere', i.e. worlds free of fundamental properties or relations that are alien to our world—but it is unclear how else to cash out what it is to be a 'world like ours'; (iii) quantum mechanics seems to serve up various kinds of non-local qualities, e.g. fundamental properties

which are instantiated at point-tuples rather than points; and (iv) the conjunction of Humean analyses of chance with the old Principal Principle leads to contradiction. Since the objections which I wish to press are not unrelated to (i) and (iii), I shall say something more about Lewis' discussion of these objections here. I have nothing to say about his responses to (ii) and (iv); I am perfectly happy to grant that he has adequate replies to them. (If others claim that Lewis' replies are inadequate, I shall not argue with them either—my interests here lie elsewhere.)[1]

Are vector fields arrangements of local qualities?

One natural question—raised, for example, by Robinson (1989)—is whether actual-world physics needs recourse to point-instantiated vector qualities which are not able to be viewed as supervening upon arrangements of scalar qualities. More generally, the question is whether actual-world physics needs recourse to point-instantiated tensor qualities which are not able to be viewed as supervening upon arrangements of scalar qualities. If some of the

[1] Since much of the philosophical dispute about Humean Supervenience has concentrated on issues concerning laws of nature, causation and chance, one might think that my setting aside issues about chances commits me to a discussion of laws and causes. Not so. Even if Humean Supervenience is compatible with a satisfactory account of laws, causes and chances, there are fundamental philosophical challenges which it must confront—or, at least, so I claim. In particular, there are various contestable assumptions about "locality"—"one damn thing and then another"—which are built into the thesis of Humean Supervenience. (In Lewis' formulation, this "localisation" is cashed out in terms of points. While this may seem rather unHumean—mathematical points were, after all, anathema to Hume—it is important to bear in mind the rest of the Humean conception of the "looseness" and "separateness" of things. Lewis' formulation seems to me to give natural expression to some typical Humean claims, albeit in a rather different context from that in which they originated.)

fundamental qualities are vectorial or tensorial in nature, can we correctly suppose that these qualities are intrinsic to spatio-temporal points?[2]

Lewis says: "I said qualities were intrinsic; that means they can never differ between duplicates; and I would have said offhand that two things can be duplicates even if they point in different directions. Maybe this last opinion should be reconsidered, so that vector-valued magnitudes may count as intrinsic properties. What else could they be? Any attempt to reconstrue them as relational properties seems seriously artificial." (474)

The problem which Robinson and Lewis are addressing concerns the intuition that things which differ by a rotation may nonetheless be duplicates: if things which differ by a rotation may nonetheless be duplicates, and if duplicates must share all their intrinsic properties, then is seems that vector (and tensor) properties cannot be intrinsic. If it is 'seriously artificial' to take vector (and tensor) quantities to be non–intrinsic, then it seems that we shall need to reconsider the opinion that things which differ only by a rotation may nonetheless be duplicates.

It does not seem obvious to me that points at which vectorial quantities of the same magnitude but different direction are instantiated may be duplicates, so I have no beef with Lewis' proposed solution to this problem. However, I do not see why the alternative proposal—holding that vector (and tensor) properties are non–intrinsic—has to be 'seriously

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[2] Note that it is only <u>fundamental</u> point–instantiated vectorial or tensorial properties which may pose a problem for Humean Supervenience. The friend of Humean Supervenience need lose no sleep over supervenient non–point–instantiated vectorial or tensorial properties which are <u>not</u> fundamental. Throughout this section, I am to be understood to be talking about <u>fundamental</u> properties.

artificial'. In particular, it seems to me to be natural to think that vector–valued (and tensor–valued) magnitudes cannot be instantiated at 'naked points', since no directions can be associated with naked points. If that's right, then whether vector–valued (and tensor–valued) magnitudes may be intrinsic depends upon the properties of duplicates of points: can a point which is embedded in a neighbourhood of points have duplicates which are 'naked', i.e. not thus embedded in neighbourhoods? If so, then vector–valued (and tensor–valued) magnitudes surely cannot be intrinsic properties of points. (Later, we shall develop this point into an objection to the idea that distance relations are fundamental in Lewis' sense. The distance between a pair of points is surely not a property of the pair of points alone: it depends upon the properties of (infinitesimal) regions of the manifold in which the point is embedded; and typically, it depends upon properties of (infinitesimal) regions of the manifold which cover geodesics connecting the points in question.[3])

There are other worries which might be raised by point–instantiated vector qualities. If one thought that, in order for a vector-valued magnitude to be instantiated at a point, there must be some neighbourhood—perhaps only an infinitesimal neighbourhood—which properly includes the point, and across which there is a vector-valued distribution, then one might have a reason for holding that vector–valued magnitudes are not intrinsic properties of points. For one might hold, consistently with the above view, that there need be no neighbourhood to which a vector-valued distribution of the kind in question is intrinsic. (I said that the neighbourhood 'properly includes' the point, but this may need refinement. First, say that in

[3] Here, and throughout my paper, I assume that, at a minimum. a spacetime requires a manifold and a metric (i.e. I am assuming something like the standard formulation of General Relativity). Similarly, when I talk about Quantum Mechanics, I am thinking about standard Hilbert space formulations of the theory.

order for a vector-valued magnitude to be instantiated at an interior point, there must be a neighbourhood of the right kind. Then add some further stipulation for boundary points, in terms of limits of sequences of interior points, or the like. These details do not matter for present purposes.)

Would this suggestion have the consequence that one cannot have an intrinsic duplicate of a point (at which a vector-valued magnitude is instantiated) which is not embedded in an intrinsic duplicate of the vector-valued magnitudes of some neighbourhood of that point? If so, then it seems that we are headed for trouble—for enough iteration of neighbourhoods, even infinitesimal, might cover the manifold; and then we would get the absurd conclusion that one cannot have an intrinsic duplicate of a point (at which a vector-valued magnitude is instantiated) except when embedded in an intrinsic duplicate of the entire world. But we can evade this *reductio*: all we require, for the intrinsic duplicate of the point, is that it be embedded in a suitable neighbourhood (not necessarily a neighbourhood which is an intrinsic duplicate of a neighbourhood in which the point is actually embedded). Moreover, even without this evasion, it is not obvious that we would necessarily be headed for trouble: it could be that we only ever get covers for (very small) sub-regions of the manifold from iterations of the kind mentioned.

Another possibility consistent with the above suggestion is that vector-valued magnitudes are intrinsic properties of neighbourhoods rather than of points, but that intrinsic duplicates of points need not share properties which are intrinsic to the regions to which they belong. So, on this view, if a vector-valued magnitude is instantiated at a point, then there is some neighbourhood to which the point belongs, and upon which a distribution of that vector-valued magnitude is intrinsic—and yet the vector-valued magnitude is not an intrinsic

property of the point. (On this view, it seems that one won't get any versions of the worry mentioned in connection with the first suggestion: one can duplicate a sub-region without duplicating a larger containing region.)

Of course, these suggestions do have costs. If you think that it is possible for a vector–valued magnitude to be instantiated at a single space–time point—e.g. that there could be a point particle which existed for an instant but which nonetheless had primitive vector–valued magnitudes—then you will deny that there is a genuine worry here: vector–valued magnitudes can be instantiated at points without being instantiated in any non–trivial neighbourhoods containing those points. Even if the quantum uncertainty relations rule this out as a nomic possibility, it is not obvious that it is not a logical possibility—so it is not obvious that there is a problem here.

Related issues might be thought to be raised by derivative quantities: rates of change at points. If derivative quantities can be among the fundamental properties on which all else supervenes, then Humean Superveniencis in trouble—for these derivative quantities are not intrinsic to points, but rather defined in terms of the values of quantities in neighbourhoods of points. Of course, one might well think that these derivative quantities cannot be fundamental—but it isn't obvious to me that this has to be right. (Is is obvious that metaphysical dependence has to 'match up' with analytical or definitional dependence?)

Whatever the status of the above speculations—and it is clear that there is much more which could be said about them—Robinson's point does raise some questions about the strength of the case for Humean Supervenience. No doubt, for all that has been said so far, the defender

of Humean Supervenience can opt to count vector–valued magnitudes amongst the intrinsic properties; but it is not obvious that this choice will be ultimately vindicated.

Does QM serve up non-local qualities?

Another natural question—raised, for example, by Forrest (1988)—is whether modern physics—in particular, quantum mechanics—serves up non-local qualities which conflict with the statement of Humean supervenience. Perhaps, owing to the various uncertainty relations, there are fundamental properties which can only be instantiated in sufficiently large regions of space-time—so that at least some fundamental properties are actually 'smeared out' perfectly natural intrinsic properties of regions of space-time (and not perfectly natural intrinsic properties of points). Perhaps, owing to strange quantum correlations, there are fundamental properties which can only be instantiated at tuples of space-time points—so that at least some fundamental properties are actually perfectly natural intrinsic properties of tuples of space-time points (and not perfectly natural intrinsic properties of points). And so on.

Lewis acknowledges that the doctrine of Humean supervenience might well need to be revised in order to accomodate these kinds of non-local qualities: "The picture is inspired by classical physics. Humean supervenience doesn't actually say that physics is right about what local qualities there are, but that's the case to keep in mind. But if we keep physics in mind, we'd better remember that physics isn't really classical. For instance, a rival picture inspired by waves in state-space might say that many fundamental properties are instantiated not at

points but at point-tuples. The point of defending Humean supervenience is not to support reactionary physics ...” (474)

Lewis’ concession here is clearly right. It could be that the fundamental properties of non-classical physics are not perfectly natural intrinsic properties of points, but rather perfectly natural intrinsic properties of point-tuples or regions of space-time. And, in that case, at the very least, the principle of Humean supervenience needs to be reformulated. But it is not clear how such a reformulation will proceed. After all, the core intuition which motivates the thesis of Humean supervenience is that fixing local physical properties—physical properties in the small—fixes all of the physical properties. Once we give up the idea that the notion of a point provides us with an intrinsic criterion for locality (smallness), it is not clear where we should search for a successor. If quantum properties can be non-local (not confined to the small), then it is not clear what can be left of the intuitive underpinnings for the thesis of Humean supervenience.

Moreover—as we shall see in more detail later—there is also room for suspicion that, in any case, Lewis’ concession does not go far enough. Given that one is going to bear non-classical properties in mind, one also needs to remember that it is not written in stone that physics is committed to any kind of classical (relativistic) space-time. Yet, once one moves to some non-classical setting which dispenses with classical (relativistic) space-time, the formulation of anything even remotely like the doctrine of Humean supervenience becomes rather more problematic. But more of that anon.

A possible response to the worry which quantum mechanics appear to raise for Humean Supervenience is to claim that, while the doctrine is not true for spacetime—or suitable

physical successors for spacetime—it is true for the fundamental space of the world. As Loewer (1996) suggests, on plausible interpretations of quantum mechanics, it remains the case that we have a fundamental space over which there is a distribution of point–instantiated complex quantities—but the space in question is configuration space rather than spacetime:

> The lesson for a defender of Humean Supervenience to take from quantum mechanics is to count a property as Humean in a world iff it is an intrinsic quality of point in the fundamental space of that world. If Bohm's theory—or any other version of quantum mechanics that construes the wave function realistically—is correct, then that space is configuration space. Given this account of quantum properties, quantum non–locality poses no threat to Humean Supervenience.

Perhaps this claim is true to the spirit of Humean Supervenience, even though it clearly violates the letter of that doctrine; however, it certainly marks a departure from the kind of picture which Lewis seemed to be endorsing during his campaign on behalf of Humean Supervenience. Moreover, it is not clear to me why one should have any firm intuition that the qualities distributed in configuration space—or whatever other space turn out to be the fundamental space of the world—must be intrinsic to the points of that space. It seems to me that, to the extent that the thesis of Humean Supervenience does have intuitive support, it derives this intuitive support from considerations about contact and action–at–a–distance in spacetime. Perhaps, though, this just reflects an ill–considered prejudice against the idea that configuration space—or some other kind of space which is not much like spacetime—could be ontologically fundamental. In any case, even if there is some (other) intuitive foundation for the idea that Humean Supervenience should be obeyed in the fundamental space of the

world, it remains to be seem whether the kinds of candidate fundamental spaces which physics currently puts on offer do fit the spirit of the doctrine of Humean Supervenience.

II

Before I turn to the objections which I should like to have considered in a judicious examination of the thesis of Humean Supervenience, I shall say something about an interesting kind of objection which I am inclined to set aside. This objection—bruited most recently by van Fraassen (1995)—is that there is no such thing as the world. Of course, if this objection is right, then the thesis of Humean Supervenience is ill-formed: it relies upon a false presupposition. So it seems germane to our present enterprise to ask: Is it really true that there is no such thing as the world? What kinds of reasons could one give for supposing that the world fails to exist?

One kind of reason might be this: We know from set theory that there are limits on the size of things, that assumptions about the existence of 'total' entities—e.g. the set of all non-self-membered sets—are apt to lead to paradox. Since the world would be a 'total' entity, we have reason to be cautious about postulating its existence.

Another kind of candidate reason is this: If the world exists, then it is a (mereological) sum: the sum of all the things which exist. In order to believe in the existence of such a thing, we need to accept the principles of mereology (in particular, the principle of unrestricted composition). But we should not accept the principles of mereology: so we have no reason to believe that the world exists.

A third putative reason is this: The expression 'the world' is only superficially a noun; in fact, it is a context-dependent term which indicates the domain of discourse of the sentence in which it occurs, on the occasion of utterance. It plays this role sometimes by denoting the domain, and sometimes by purporting to denote an entity of which the members of the domain are parts. However, in the latter case, we need not take the purported denotation seriously; rather, it should be construed as metaphor, colorful language, rhetorical extravagance, or the like. In all cases, then, the important semantic function is merely the contextually-constrained indication of the domain of discourse. Consequently, there is never good reason to suppose that 'the world' really refers to an entity.

None of these arguments strikes me as very impressive.

First, while it is true that some kinds of assumptions about the existence of 'total entities' lead to contradictions, it is hard to see what relevance this has to the existence of worlds. Suppose, for example, that one thinks of worlds in the way that Lewis (1986) does: i.e. as maximal collections of suitably externally related objects (the model for the external relations being classical spatiotemporal relations). Whatever problems one thinks there are with Lewis' story, one should not think that there are cardinality problems which arise just given the worlds. Even if one took the worlds to be sets of objects, it isn't clear that troubles would arise —it's not as if we must be supposing that there are proper class many objects in each world, or that there are proper class many worlds[4]; and, in any case, it would just be a mistake to think that the worlds are sets of objects. On the contrary, the objects are parts of

[4] Lewis (1986) certainly does not allow that there are proper class many worlds, or that there are worlds which have proper class many parts. For a contrasting view—and for an explanation of some of the benefits which might accrue—see Nolan (1996).

the worlds—and the mereological relation which this involves is not a relation which generates.

Second, while it is true that belief in the principle of unrestricted mereological composition might play a role in arguments for the existence of the world, one is not obliged to believe that principle in order to accept the conclusion that the world exists (and, in any case, there are reasons for thinking that there is nothing wrong with the principle of unrestricted mereological composition). One might think, for example, that whenever one has some things, there is a thing of which all those things are parts, while denying that, whenever one has some things, there is a thing which is exactly the mereological sum of those things. In other words, perhaps the principle of unrestricted mereological composition is false, and yet it is impossible for there to be two things which are not both parts of the same thing. (By 'part', I mean 'proper or improper part', of course.) Consequently, it is just a mistake to think that commitment to the existence of the world requires commitment to the principle of unrestricted mereological composition (or, indeed, to any other objectionable mereological principles).

Third, it isn't plausible to suggest that 'the world' is—or could always be—understood distributively in ordinary language (and that when thus understood, there must always be some contextually supplied restriction on the distributed collection). Clearly, we do ordinarily make claims in which 'the world' must be understood collectively: 'The world is an awesome place', 'God's world is perfect', and so on. No argument from ordinary language or ordinary practice can show that these claims are unintelligible. Moreover, it is a commonplace amongst cosmologists—both pre-scientific and scientific—that the world exists. One could not understand what they say unless there is some sense in which one understands the

collective, unrestricted, use of the expression 'the world'. No doubt, it is perfectly correct to claim that 'the world' often functions as a restricted distributive quantifier: but there is no argument from this data to the conclusion that 'the world' never functions properly as an unrestricted collective quantifier.[5]

Another kind of reason which some people have thought to give for denying that there is anything such thing as *the* world turns on an alleged ambiguity, or discourse relativity, in the interpretation of the existential quantifier. On this Carnapian view, there are different kinds of discourses and, for each discourse, the internal question whether the kinds which the discourse quantifies over exist is trivial (analytic), the external question whether the kinds which the discourse quantifies over is purely pragmatic (is it useful to continue using this discourse?), and there is no other intelligible question about existence to be asked. So, in particular, there is no way of asking, in the one breath, whether objects which belong to different discourses (or frameworks, or theories) exist—and hence there is no sense to be given to the question whether there is one world or many.

Even if this Carnapian position could be vindicated—and I must confess that my money is on the Quinian alternative which denies the Carnapian distinction between different senses of the existential quantifier—there is no reason to think that it is relevant to our present concerns. After all, we can take it that our question is one about the physical universe—i.e. the subject of investigation of physical cosmology. True enough, the thesis of Humean Supervenience

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[5] It's curious that van Fraassen just ignores that part of the OED definition of 'world' which doesn't fit his case, viz: 'the universe, or a region of it'. Perhaps uses in this sense are all metaphorical, or colorful, or rhetorically extravagant -- but, if so, this needs to be argued from metaphysics (i.e. it is not a conclusion which is supported by the merely linguistic data).

will allow us to go on to say that, in some sense, this is all the world that there is: but the assumption that there is a single physical world (which is all that the present kind of objection is putting in doubt) is not one which the Carnapian thesis tells against.

Perhaps there is some other reason why we should not suppose that there is any such thing as the world. However, I can't imagine what those reasons could be. Moreover—putting into practice the motto that the best form of defence is attack—there are positive reasons why we should think that there is such a thing as the world. In particular, it is hard to imagine what alternative is supposed to be put in place of this assumption. There are things that stand in physical relations. What could it possibly be like for there to fail to be a total of things which stand in these kinds of relations. Compare: There are some people under the roof. What could it possibly be like for there to fail to be a total of people under the roof? True enough, there might be cases for semantic decision: borderline cases of people, borderline cases of being under the roof, and the like. But we can precisify, and then get determinate answers. In this case, we might end up with bounds, rather than a definite answer. But nothing like that could happen in the case of the physical universe—so what problems could there be left to face?

Furthermore, it is—and has been for at least seventy years—standard practice for scientific cosmologists to suppose that there is a unique physical world, which their theories seek to model and describe. If you spend a bit of time reading popularisations of scientific cosmology and informal expositions of theories in scientific papers, you will find that it is virtually impossible to resist the conclusion that almost all scientists naturally suppose that there is a unique world. In these circumstances, it seems natural to me to think that some very powerful argument is required before this assumption should be given up.

III

I now turn to the discussion of four potential objections to Humean Supervenience. Of these, the last is the one upon which I wish to place most emphasis (though the third is also one which deserves serious consideration). Perhaps the most important feature of these objections is that they involve considerations which at least some respectable physicists are disposed to take seriously. (The significance of this feature will be discussed in the next section.)

(i) There are no fundamental properties and/or relations.

One presupposition of the thesis of Humean Supervenience is that there are *fundamental* properties and relations. That is, the thesis of Humean Supervenience assumes that there is some *minimal* or *irredundant* collection of properties and relations upon which all other properties and relations supervene.[6] Once this assumption is stated, it is easy to see how it *could* be false: It could be that for any properties and relations, there are subvenient properties and relations upon which the given properties and relations supervene. In Wiechert's phrase, the world could be 'infinite in all directions' —and, in particular, new subvenient properties and relations could continue to appear as one moves to (say) ever higher energy levels.

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[6] Strictly, the claim about minimality of irredundancy is not explicit in Lewis' presentations of Humean Supervenience. I take it, however, that it is a natural assumption to make; and that it is an assumption which those who are sympathetic to combinatorialism about possibility are likely to make. (If there were redundancy in the supervenience base, then there would be necessary connections between the properties in the base. To some ears, that might even sound a little non–Humean ...)

Of course, the mere recognition of this possibility does not suffice to show that is it plausible. Moreover, there are various considerations which might seem to militate against it. In particular, we do not have any evidence that the world has an interesting, new structure below, say, 10^{-15} cm. (Perhaps recent experiments might be taken to contradict this claim; in that case, the bound should be revised down by a few orders of magnitude.) Moreover, we don't have any independent compelling theoretical reasons to postulate interesting new structure below about 10^{-36} cm.[7] (Likewise, we don't have any independent compelling evidential or theoretical reasons to postulate interesting new structure beyond the level of superclusters of galaxies.) Consequently, considerations of theoretical economy might suggest that it would be rather rash to suppose that the world is infinite in the small (or the large).

However, the question is not whether we have good reason to rule the possibility in (it's clear that we do not); rather, the question is whether we have good reason to rule it out. If we commit ourselves to the thesis of Humean Supervenience, then we are committing ourselves to the claim that the world is not infinite in all directions. I see no good reason for us to do this. It costs us very little to remain neutral on this question; so we should do so (at least until physics tells us that we must do otherwise). Moreover, our doing so need have no bearing at all on our determination to insist that everything supervenes on the micro-physical.

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[7] Given the aims of this paper, it might seem safer to characterise the domains in questions in terms of energy levels rather than in terms of measurements of length. (The energy levels in question characterise the particle accelerators which we would need to build in order to probe these domains.) However, we can use a false theory to characterise a domain—(very roughly) these lengths pick out the domains which these lengths would have picked out if the world were embedded in a classical spacetime.

Apart from considerations about qualities, there are also questions about the spatio-temporal relations. Consider distance relations. It seems plausible to claim that, e.g., no distance relation—e.g. 'being one metre apart'—is fundamental: the distance between any two distinct points supervenes on the (smaller) distances between intermediate points (which lie on extremal curves connecting the points). More generally, it seems plausible to claim that all of the spatio-temporal relations share this property: the spatio-temporal relations of larger regions of space-time supervene upon the spatio-temporal relations of smaller regions of space-time which are parts of those larger regions. (Ultimately, perhaps, all of the spatio-temporal relations supervene upon the spatio-temporal relations of infinitesimal regions of space-time.) If this is right, then it seems plausible to think that there are no *fundamental* spatio-temporal relations— i.e. no minimal, irredundant collection of spatio-temporal relations upon which all others spatio-temporal relations supervene.

Although I say that these claims about distance relations are plausible, they can be denied. Suppose, for example, that there could be a world just like ours, except for the fact that it contains a spacetime gap—some part of spacetime has been removed. If one were to hold that the distances between points on either side of the gap are just what they would have been if the gap were filled in, then one would be denying the claim that distance relations necessarily supervene on shorter–range distance relations. I think that one ought to insist that the distance between points on either side of the gap is determined by the shortest path through spacetime between the two points—but it would take me too far afield to try to argue the case here.[8]

[8] For discussion of this kind of issue, see Bricker (1993). If you are inclined to think that, in the example I discuss, the distance between the points on either side of the gap is just what it would have been were the gap filled in, then it seems to me that you ought to judge that the distance between any two points is what it would be were there a spacetime wormhole of the shortest possible magnitude connecting those points. But that thought just plays havoc with our ordinary judgements about

Even if you don't like the idea that there might be no fundamental properties and/or relations, I hope that you will agree that there is no *a priori* reason why things might not turn out this way—or else that you think that you can construct an argument for the conclusion that there must be fundamental properties and/or relations which I will find convincing. I would like to see such an argument.[9]

(ii) There are more fundamental relations given by physics.

Another presupposition of the thesis of Humean Supervenience is that the only fundamental relations are spatio-temporal relations—i.e. there are no more fundamental relations than these. Again, once the assumption is stated, it is easy to see how it could be false: It could be that there are other fundamental relations—i.e. relations which do not supervene upon the spatiotemporal together with the fundamental properties, but which are required in order to have a subvenient basis for all properties and relations.

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distances: it is surely logically possible that there be a spacetime wormhole along which the distance from a point in Melbourne to a point in Sydney is eighty metres; nonetheless, the distance from Melbourne to Sydney is over eight hundred kilometres.

[9] Similar considerations to those raised in this section might also be raised in the context of spatiotemporal theories which take spatiotemporal regions to be primitive. If—as Whitehead held—points are mere abstractions—limits of nested sets of regions—and regions are real, then there may be some reason to think that the world has a "Russian doll" structure. While I don't think that these theories are particularly plausible, I certainly don't think that they can be ruled out *a priori*. (Analogous considerations also apply to the idea that there are no categorial properties: while I don't think that it is clear *a priori* that there cannot be dispositional properties "all the way down", I don't think that it is plausible to claim that this is actually the case.)

Again, the mere recognition of this possibility does not suffice to show that it is plausible. Moreover, it is doubtful that we yet have compelling reason to suppose that we need both spatiotemporal relations and further relations (together with the fundamental properties) in order to obtain a subvenient basis on which all else supervenes. Given that the frame of the world—at least according to our best theory—is a spatio-temporal manifold, it seems plausible to think that all we need do is to fill in the intrinsic properties of points and point objects in order to obtain a subvenient basis on which all else supervenes.

Of course, one might think that QM already provides a counterexample to the claim that the only fundamental relations are spatiotemporal (cf. the above discussion). This is a controversial question for various reasons. For one thing, it isn't clear that QM does yield fundamental relations other than spatiotemporal relations—some interpretations may say that it does, but other interpretations seem to say that it does not. (Thus, for example, it seems to me that Bohmian interpretations of QM do not yield fundamental relations other than spatiotemporal relations.) For another thing, there are hard questions about the consistency of QM—questions raised by the measurement problem—which remain to be faced. Since no fundamental theory can be inconsistent, it may well turn out that QM is not a fundamental theory—and hence it will not do as a basis for fundamental metaphysics. At best, a qualified conclusion is required: it may be that QM tells us that there are fundamental relations other than spatiotemporal relations—but it is too early to make a properly considered judgement.[10]

[10] Earlier comments about Loewer (1996) are relevant here: if you are allowed to switch to configuration space when constructing the thesis of Humean supervenience, then it is not so clear that quantum mechanics makes problems for the thesis (even if quantum mechanics does turn out to be fundamentally correct).

(iii) *Classical* spatiotemporal relations are not fundamental

Suppose it is granted that spatiotemporal relations are fundamental. Yet another presupposition of the thesis of Humean Supervenience is that *these* fundamental spatiotemporal relations are of a familiar, classical kind. In Lewis' formulation of the thesis of Humean Supervenience, he says that distance relations are fundamental—and I take it that this means that he is supposing that distance relations remain well–defined even as we move to very tiny (even infinitesimal) neighbourhoods. But many physicists seem to think that the world has no stable metric nor even stable topology 'in the small'—and if that is the case, then it is hard to see how distance relations can be fundamental.

There are several reasons why one might be doubtful that the spacetime structure of the world is classical 'all the way down', though not all of them are equally compelling. Perhaps the strongest argument begins with the observation that the two foundational theories of modern physics—GTR and QM—are mutually incompatible. One way to bring out this incompatibility is to observe that, in all standard formulations of QM, there is a pre–determined spacetime background; but in all standard formulations of GTR, spacetime is a dynamically varying structure. In order to put these theories together—in order to produce a quantised theory of gravity—it seems that there will need to be a quantisation of geometry. But natural attempts to quantise geometry lead straight to topological fluctuations, 'spacetime foam', and the like. (See Wheeler (1957) and Hawking (1978).)

Other considerations which are sometimes taken to show that it is unlikely to be the case that the structure of spacetime is classical all the way down include: the Hawking–Penrose singularity theorems in GTR (which are often taken to indicate the need for quantisation of

geometry); the divergences which arise in quantum field theories (particularly those cases in which the divergences are non–renormalisable); and the various kinds of non–local phenomena which appear in QM (EPR-type effects, the Aharanov–Bohm effect, and so on). In all of these cases, the argument for non–classical spacetime structure at 'small scales' seems to me to be less than entirely compelling—so I shall not worry about further discussion of them here.[11]

The problem of reconciling GTR and QM has led many physicists to think that there is bound to be 'new physics' below the Planck length. However, these reasons are more often reasons for thinking that no spatiotemporal relations are fundamental, rather than just that classical spatiotemporal relations are not fundamental—and that is the business of the next subsection. Perhaps it is really obvious that the idea that non–classical spatiotemporal relations are fundamental is bound to be unstable—it is hard to get much of an intuitive grip on talk about 'spacetime foam' and the like—but, even if that isn't right, it does seem to me that the idea that no spatiotemporal relations are fundamental poses a much stronger threat to Humean Supervenience. (Maybe it is also worth noting that, when physicists oppose the idea that there is bound to be 'new physics' below the Planck length, very often those reasons seem to involve verificationist or positivistic scruples: 'it is impossible to give (operational) meaning to a manifold spacetime below the Planck scale'. This kind of attitude is straightforwardly in conflict with the kind of realism about spacetime—or fundamental space—which is evident in the thesis of Humean Supervenience.)

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[11] It is clear that some of these arguments would be ruled out simply by the insistence that Humean Supervenience only applies to configuration space. For example, as Loewer (1996) points out, EPR–type effects and Aharanov–Bohm effects pose no threat to this modified doctrine. However, some of the other worries—e.g. those raised by divergences and singularities—would, I think, survive *this* kind of response.

Finally, it is perhaps also worth noting that the argument of this section is not just directed against the idea that the standard mathematical continuum does not well–describe the 'small scale' structure of spacetime. Physicists have explored the idea that spacetime might have a discrete, lattice–like structure (see, e.g., Schild (1948)(1949), Hill (1955), Regge (1961), Finkelstein (1969), Cole (1970), Creutz (1985)); and they have also explored the idea that spacetime theories might be based upon mathematical fields other than the field of the standard real numbers (see, e.g., Horzela et. al. (1992), Winterberg (1993)). On both of these kinds of suggestions, it could still turn out that distance relations are fundamental, although the distance relations in question would not be those of the familiar continuous case. I take it that these possibilities need pose no threat to the thesis of Humean Supervenience. Provided that one has an intrinsic characterisation of locality—of the kind provided by the notion of a point—then there is no problem about formulating a thesis of Humean Supervenience; and in discrete spacetimes, and spacetimes based on other mathematical fields, it seems that one will have this.

(iv) Spatio-temporal relations are not fundamental.

A final presupposition of the thesis of Humean Supervenience is that spatio-temporal relations are fundamental—i.e. that spatio-temporal relations are part of the subvenient basis upon which all else supervenes. And, yet again, once the assumption is stated, it is easy to see how it could be false: It could be that the fundamental relations which belong to the subvenient basis upon which all else supervenes are not spatio-temporal relations (and nor are they systems of external relations which are suitably analogous to spatiotemporal relations). There are then at least the following two possibilities for spatio-temporal relations: (1) they

are supervenient relations, fixed by an underlying subvenient basis; (2) they are not, strictly speaking, instantiated in the world (though they are approximately instantiated, when certain kinds of physical limits are taken).

Both of these possibilities have been recently explored by physicists under the heading of 'quantum pregeometry'. As I have just suggested, the fundamental idea is that the world has an underlying structure which is 'prior' to spatiotemporal structure—e.g. that it has the primitive structure described by Penrose's twistor theory (see, e.g., Penrose (1967)(1987)), or by some kind of non–commutative geometry (see, e.g., Aschieri and Castellani (1993)), or by Ashtekar's loop space representation (see, e.g., Ashtekar (1991)), or by some kind of non–Archimedean geometry (see, e.g., Aref'eva and Frampton (1991)), or by Clifford algebras (see, e.g., Frescura and Hiley (1980)), or by one or another kind of string theory (see, e.g., Gross (1990), Polchinski (1996)), or ... . On some of these views, spatiotemporal relations supervene on the underlying fundamental relations; on others, spatiotemporal relations are only approximately instantiated in the world (under the taking of certain limits). Sometimes, it is hard to tell which of these two alternatives is intended.[12]

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[12] Consider, for example, the following remarks from Witten (1996:24, 28):

> Our basic ideas about physics went through several upheavals early this century. Quantum mechanics taught us that the classical notions of the position and velocity of a particle were only approximations of the truth. With general relativity, spacetime became a dynamical variable, curving in response to mass and energy. Contemporary developments in theoretical physics suggest that another revolution may be in progress, through which a new source of 'fuzziness' may enter physics, and spacetime itself may be reinterpretted as an approximate, derived concept. .... We are far from coming to grips fully with this paradigm, and one can scarcely now imagine how it will all turn out. But two remarks seem fairly safe. First, all the vicissitudes of two–dimensional field theory and statistical mechanics are reflected in 'spacetime', leading to many striking phenomena. Second, once a [the new parameter characteristic of string theory] is turned on, even in the classical world with h=0, 'spacetime' seems destined to turn out to be only an approximate,

On any of these approaches, it will turn out that distance relations—and indeed, anything remotely like distance relations—are not fundamental. Thus, the letter of Lewis' formulation of Humean Supervenience will be violated. More importantly, on some of these approaches, it seems to turn out that there is no candidate intrinsically local entity which can play the role that points play in classical spacetime. Perhaps it is the case that in string theory, strings play this role—but it's hard to tell, because it's hard to tell at the moment exactly what the primitive commitments of the theory are. (This problem is common to all of the theories in the area. This is one reason why the conclusions of this paper are going to be very tentative.)[13]

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derived notion, much as classical concepts such as the position and velocity of a particle are understood as approximate concepts in the light of quantum mechanics.

These remarks *seem* to bear out the idea that, in string theory, spatiotemporal relations are only approximately instantiated in the world. But it is hard to tell for sure.

[13] Consider, for example, the following passage from Polchinski (1996:1256): "String theory .. starts with a flat spacetime. One discovers first that the spacetime is dynamical, that the theory contains gravity. Later, one finds .. that spacetime topology is not a physical invariant but can change in specific and controlled ways. There is still more to be learned. In perturbation theory it seems that the shortest sensible distance is the string length scale. ... There is evidence for a somewhat shorter scale in the exact theory, and evidence that D–branes may probe it. Moreover, there is a sense in which the spacetime coordinates for D–branes are elevated from numbers to matrices, only at low energy the matrices are diagonal and an ordinary spacetime picture holds. It may turn out that this is a curiosity, or it may signal a new uncertainty principle relating to a minimum distance. Exploring the connection between D–branes and black holes is a likely way to learn which. In effect, string theory is smarter than we are. It knows what spacetime is, and we don't, and we have to figure out how to ask it." This passage suggests that there are some grounds for pessimism concerning the likelihood that we will find out what the primitive ontological commitments of string theory are any time soon.

Perhaps—following the example of Einstein—one might dig in one's heels and insist that there have to be intrinsically local entities in all of these theories. Maybe that would be right—but it isn't obvious to me that it has to be right. (There are, of course, more *outre* suggestions on which one fails to get intrinsically local entities—e.g. those 'process' theories on which spacetime is an emergent property of an underlying 'process' (see, e.g., Bohm (1980), Monk (1997)). However, I don't propose to consider these kinds of alternatives here.) At any rate, before *I* invest in the thesis of Humean Supervenience, I want to be convinced that physics will tell us that there are appropriate intrinsically local entities which bear the fundamental properties and relations on which all else supervenes (as the thesis maintains).

IV

Lewis (1994) qualifies his defence of this principle by remarking:

> The point of defending Humean supervenience is not to support reactionary physics, but rather to resist philosophical arguments that there are more things in heaven and earth than physics has dreamt of. Therefore if I defend the philosophical tenability of Humean Supervenience, that defence can doubtless be adapted to whatever better supervenience thesis may emerge from better physics.

In view of this qualification, one might wonder whether there is any life in the horse which I have been flogging. Lewis himself is happy to concede that the thesis of Humean supervenience may fall with future physics. So, even if what I have said is news, it isn't important news: We already knew that the principle of Humean Supervenience might well be inconsistent with our best physics (present and/or future).

But wait. If Lewis' defence of the 'philosophical tenability' of Humean Supervenience is to have any value (in the event that the principle turns out to be false), it had better be the case that—as he predicts—his defence of it can be adapted to 'whatever better supervenience thesis may emerge from better physics'. But that may not be the case. It seems to me that it is crucial to Lewis' thesis of Humean Supervenience—and to his defence of it—that there are intrinsically local entities which are the bearers of the fundamental properties and which stand in the fundamental relations. If so, and if it turns out that physics gives us a theory on which there are no intrinsically local entities, then I think that it will not be so that Lewis' defence of Humean Supervenience can be adapted to the better supervenience thesis which will emerge from that new physics.

Is this a serious worry? I'm not sure. It seems to me that physicists currently take this possibility seriously. If that's right, and if we think that our best physics should be our first guide in metaphysics, then it seems to me that, at the very least, we should be cautious about endorsing anything like the principle of Humean Supervenience. It could be that this principle is on the right track; but, for all that physics currently tells us, it may also be that it is heading off in a completely misleading direction.

(Lewis also discusses these matters in the Introduction to Lewis (1986), pp.x–xi:

> I have conceded that Humean supervenience is .. an empirical issue. Then why should I, as philosopher rather than physics fan, care about it? ... Fair enough. Really, what I uphold is not so much the truth of Humean supervenience as the *tenability* of it. If physics itself were to teach me that it is false, I wouldn't grieve. That might happen. ... But I am not

> ready to take lessons in ontology from quantum physics as it is now. ... What I want to fight are *philosophical* arguments against Humean supervenience. When philosophers claim that one or another commonplace feature of the world cannot supervene on the arrangement of qualities, I make it my business to resist.

Taking Lewis at his apparent word here, the considerations which I have raised in this paper really are irrelevant. If all Lewis wants to hold is that there are possible worlds in which the doctrine of Humean Supervenience holds—hence that all of the commonplace features of the world *can* supervene on the arrangement of qualities—then I do not wish to disagree. (Remember, I am not taking any stance on the issues raised by the big bad bug of objective chances.) Likewise, if all that Lewis wants to claim is that there can be no *a priori* ('philosophical') defeat of the claim that our world is one in which Humean Supervenience obtains, then again I do not want to disagree—though I would insist that if we are only taking *a priori* considerations into account, it is hard to see that there is more reason to be for it than that is to be against it. However, I take it that the kind of speculative metaphysics in which Lewis engages is not, and should not be, a purely *a priori* endeavour. In particular, one important desideratum is that our metaphysical theory should be true—i.e. true of the actual world. Consequently, one way to threaten the tenability of speculative metaphysical theories is to show that they rely on assumptions which are under empirical threat (particularly in cases where there is also threat that those assumptions cannot be re–jigged in some way which avoids the empirical threat). I think that there may well be sufficient grounds for holding that there is sufficient empirical—current scientific—threat to the doctrine of

Humean Supervenience that we should be loathe to invest too many of our philosophical resources in it.)[14]

V

If I am right that micro-physicalists should not feel entirely comfortable with the doctrine of Humean Supervenience, then the question clearly arises of what to put in its place. In particular, a familiar question about the content of the doctrine of micro–physicalism once more appears to raise its head, viz: what exactly is it that micro-physicalists believe? I began by saying that I would like to endorse a thesis of microphysical supervenience—but what kind of thesis is that?

This kind of question has been discussed quite a bit of late. For example, Crane and Mellor (1990) deny that it admits of a satisfactory answer: in their view, there is no formulation of physicalism (let alone microphysicalism!) which is neither trivially true nor obviously

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[14] Even if you agree with me that there is something dubious about the appeal to fundamental external relations in Lewis' formulation of the thesis of Humean Supervenience, you might think that there is still something intuitively right about that picture; and, in particular, you might think that there is something fundamentally right about the Humean intuition that there are no necessary connections between distinct existences. Perhaps this much of the doctrine of Humean Supervenience will be retained, come what may—but that is a matter for further research. (Similar considerations apply to the question whether my objections to Humean Supervenience, if successful, would severely damage Lewis' general philosophical programme. Given that the doctrine of Humean Supervenience incorporates several distinct intuitions—and given that it is intended to play several different roles—it may be that almost all of Lewis' philosophical programme will survive even if the doctrine of Humean Supervenience does not.)

false.[15] Well, what's wrong with the formulation that I gave at the beginning of my paper: *microphysicalists hold that microphysics provides a subvenient basis upon which all else supervenes: fix the microphysical properties of a world like ours and one fixes all the properties of a world like ours*? (By 'microphysics', I do not mean current microphysics; rather, I mean true and complete microphysics (a theory which we may never have). This formulation of microphysicalism is due (essentially) to Frank Jackson, who often casts it in something like the following form: *Any world which is a minimal microphysical duplicate of our world is a duplicate in all respects of our world*.)

I take it that this formulation is not vulnerable to worries about how to draw the boundaries between the properties which belong to the subvenient basis and the rest. Since I am not requiring that we find a minimal (irredundent) subvenient basis, it will suffice to say that microphysics provides the theory of 'the sufficiently small' (say, at the level of atomic constituents and 'below'). No–one seriously disputes that only physics tells us about this domain—and so there is no straightforward objection on grounds of circularity to the claim that, in principle, everything reduces to microphysics as thus construed.[16]

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[15] For further discussion, see Braddon–Mitchell and Jackson (1996), Crane (1990) (1993), Horgan (1982), Mellor (1993), Menuge (1993), Moser (1996), Papineau (1990) (1991), and Pettit (1993).

[16] Compare with Crane and Mellor, pp.188ff. If supervenience entails reduction in principle—as many people suppose—then the objections which Crane and Mellor make to reduction in principle are also objections to supervenience. If supervenience does not entail reduction in principle—as many other people suppose—then my remarks about reduction in principle here and throughout the next few paragraphs are irrelevant.

I also take it that Crane and Mellor are wrong to claim that the physics of the relatively large does not reduce in principle to microphysics (hence, perhaps, that the physics of the relatively large does not supervene on microphysics). They say:

> If .. we take the quantum mechanical description of a quantum ensemble to be complete .. the superposition principle entails that its properties will not be a function only of those of its isolated constituents plus relations between them. Orthodox quantum physics is not microreductive. And some physics is positively macroreductive: Mach's principle, for example, which makes the inertial mass even of microparticles depend on how matter is distributed throughout the universe. ... And even in the most ordinary physics, MR does not always hold. ... Suppose for instance that [a gas] sample's volume is suddenly halved at a constant temperature. If the gas is ideal, Boyle's law entails that when its pressure settles down again it will be twice what it was. That law does not dictate all the interim behaviour of the sample's molecules—except that it must be such as will eventually double the sample's pressure. That much of their behaviour is determined .. macroreductively by a law governing the sample as a whole. (190)

In no case is the conclusion which Crane and Mellor draw correct. Even if it is true that the superposition principle entails that the properties of a quantum ensemble are not a function of the properties of the isolated constituents plus relations between them, that does nothing at all towards showing that the properties of that ensemble could differ even though no microphysical properties of the world differed. Even if Mach's principle were correct—which is highly doubtful *even* according to General Relativity—all that would follow is that the inertial mass of a given microparticle depends upon the distribution of microparticles (and fields) throughout the rest of the universe; and that is no barrier at all to supervenience upon, or reduction to, the microphysical. Even if we suppose that we have an ideal gas (which we never do), there is no reason at all to suppose that we need to advert to macroreduction in order to explain why it conforms to Boyle's law—after all, the detailed spelling out of what happens at the microlevel on any occasion when the volume of the gas is halved will entail the detailed spelling out of a scenario on which the pressure is doubled, and hence there is bound to be microphysical supervenience and reduction.

Finally, I take it that Crane and Mellor are wrong to claim that even the weakest serious supervenience theses are undermined by the indeterminism of modern physics. They claim that modern indeterministic physics must predict that some minimal physical duplicates will differ in non–physical respects. Even if this were so—and it is worth pointing out that it is only according to certain interpretations that modern physics is indeterministic—it need not threaten the supervenience thesis which I wish to accept. (It would do so if modern physics predicts that there are minimal physical duplicates of entire worlds which differ in non–physical respects. But the argument does not show this.) And in any case, their argument is plainly question–begging. What they say is this:

> Suppose an intrinsic non–mental property P causes a mental property M indeterministically. (Say for example that one's chance of being M at t_2 is 0.9 if one has just been P (at t_1), and 0.1 if one has not.) Suppose that at t_1 many people share all their intrinsic non–mental properties, including P. At t_2, therefore, most but not all of them will be M: that is, some pairs of people, atom–for–atom alike at t_1, will differ at t_2 in this mental respect. Now let a and b be any such pair: at t_2, a is M and b is not. What about a's and b's intrinsic non–mental properties at t_2? Well, these may all be determined by a's and b's shared non–mental state at t_1. But, if so, then they too will all be shared, and M will not supervene on them either. But M will not supervene on them anyway. For even if some relevent laws of physics are indeterministic, so that a's and b's state at t_1 does not make them share all their intrinsic non–mental properties at t_2, it still will not stop them doing so. On the contrary: given enough such as and bs, some will certainly differ mentally at t_2 without differing in any other way.

But, if the doctrine of microphysical supervenience is correct, then there must be some physical difference in those people who are M at t_2 but not at t_1, and the scenario which Crane and Mellor describe is simply impossible. The case which Crane and Mellor describe relies on the assumption that P does not cause M indeterministically by causing the appropriate

change in the subvenient basis for M indeterministically—and this reliance plainly begs the very question at issue.[17]

Even if these objections to the arguments of Crane and Mellor are correct, there is clearly more work to be done in providing a justification for microphysicalism. In particular, it is worth noting that I have done nothing towards offering positive reasons for believing in the doctrine. Fair enough. My reasons for being well–disposed towards the doctrine of microphysicalism are twofold: first, it accords with my intuitions; and second, if it is correct, it secures certain theoretical advantages (in particular, a reduction in the primitive ontological and ideological commitments which one is required to make). Perhaps these aren't much in the way of arguments to try to persuade others to accept the doctrine; but they do seem to be sufficiently substantial reasons for me not to give it up.[18]

(We have already noted that Lewis claims that the point of defending Humean supervenience is to resist philosophical arguments that there are more things in heaven and earth than physics has dreamt of. However, one needn't espouse Humean supervenience—nor even any

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[17] Perhaps this criticism does not apply to the argument which Crane and Mellor intended to give—cf. the complaint in Mellor (1993) that their argument presupposes the success of their earlier objections to the thesis of macroreduction, etc. However, it *is* worth pointing out that Crane and Mellor have no case against (weak versions of) supervenience if those earlier objections fail.

[18] Actually, there is quite a bit more which I would be prepared to offer on behalf of microphysicalism. In particular, I hold that there are good reasons for thinking: (i) that the microphysical world is causally closed (there is no "downward causation" from higher levels); and (ii) that many non–microphysical properties can be "placed" in the microphysical domain. However, I am not confident that there are the materials for a non–question–begging argument here. In any case, this is material for another occasion: I would be more than happy *first* to secure agreement on the claim that microphysicalism has not yet been defeated.

kind of microphysical supervenience—in order to deny that there are spooks, entelechies and other unphysical things. In order to deny that there are more things in heaven and earth than physics has dreamt of, all one needs to hold is a doctrine of physical supervenience: all contingent matters of fact supervene on physical matters of fact. (Perhaps all one needs to hold is a doctrine of physical constitution: every contingent thing is composed without remainder of physical things. That seems to rule out spooks, entelechies, and other *un*physical things, while still leaving it open that there are *non*–physical things with non–physical, emergent, intrinsic or essential properties.) So I don't think that we can find a good motivation for microphysicalism here.)[19]

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