Chapter 7: The Nonreductivist's Trouble with Explanation

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Recall that a central application of grounding is to the explication of the idea of layered structure. Though the idea of layered structure is topic-neutral, I will continue to illustrate its features and import by appeal to the relation between the physical facts and the biological facts. So, I have assumed, every biological fact is dependent on and determined by some congeries of physical facts.[1] In Ch. XXXXX, we reviewed a proposal that identifies the kind of dependence and determination at issue with grounding. On this proposal, the layered structure of *facts* was given by a specification of what grounds what. So, one chunky fact is less fundamental than another iff the latter (partially) grounds the former. The idea that one *class* or *kind* of facts is less fundamental than another can then be explicated in terms of the specification of what grounds what by a proposal due to Gideon Rosen [CITE!]. So, for instance, the idea is that the biological facts are less fundamental than the physical ones in roughly the sense that every biological fact obtains in virtue of some physical fact. There is a correlative notion of fundamentality for entities, due to Michael Raven [CITE!]: roughly an entity is fundamental iff its existence and features are all grounded

[1] My informal exposition in this chapter will deploy factualist resources. Officially, our regimentation of grounding claims is operationalist, so it is important to note that the arguments in this chapter can all be regimented in an operationalist framework. I will suggest how this might be done in footnotes. The key in every case is simply to introduce sentential operators to express key ideas in operationalist terms, and use quantification into sentential position to express generalizations. So, for instance, we encountered in Ch. XXXXXX Correia's factual equivalence operator $\approx$ which takes sentences on either side. This operator can be used to express identity reduction. So, where we would say informally that the fact that ϕ is identical to the fact that ψ, we can instead use $\approx$ to say $\phi \approx \psi$. Similarly, instead of saying that ϕ expresses a biological fact, we may introduce a sentential operator 'ϕ is biological', where as we have been assuming, a fact is biological iff it is expressed by a truth of final biology. (Similar remarks apply to our expression of the idea that a fact is physical, economic, *etc.*) Then ϕ is *properly biological* iff ϕ is biological and ϕ is not physical.

in the existence and features of other entities. So, for instance, genes, epidemics, organisms, clades, and biological processes all exist and have the features they do in virtue of certain congeries of physical facts.

Grounding is typically taken in the literature to be a way of making sense of the idea of layered structure that does not require reduction. However, we have also seen in Ch. XXXXX that, even if every fact is reducible to some physical fact, something like the notion of grounding is needed in addition to the notion of reduction to capture the idea of layered structure. Still , it might reasonably be held that the role of grounding in the reduction-based conception of relative fundamentality is auxiliary; see Ch. XXXXX, §YYYYY for discussion.

In any case, a nonreductive physicalist view about the relationship between the biological facts and the physical facts is to be contrasted with a reductive view. The nonreductive view holds that, though all biological facts are grounded in some congeries of physical facts, some biological facts are *properly* biological facts:[2] that is, they are distinct from any physical fact. The reductive view, by contrast, holds that all biological facts are identical to some physical fact and are, furthermore, grounded in congeries of (further) physical facts. Both reductive and nonreductive physicalist views are to be contrasted with a dualist view on which either the existence or some feature of some properly biological entity – some gene, epidemic, organism, clade, or biological process for instance – is not grounded in any congeries of physical facts. Finally, all three of these views are to be contrasted with a certain straighforward eliminativist view which denies the truth of all biological claims concerning *e.g.*, genes, epidemics, organisms, or clades.[3] So, with respect to a particular, recognizably biological claim like

(1) Metabolism occurs in the cells of living organisms

we have a spectrum of views:

Straightforward Eliminativism (1) is false.

Reductivism (1) expresses some physical fact grounded in some congeries of (further) physical facts.

[2] See Ch. XXXXX, §YYYYYYY.

[3] Straightforward eliminativism of this sort is to be contrasted with the sort of conciliatory irrealism explored in Ch. XXXXXX. The conciliatory irrealist accedes to the truth of sentences like (1), holds that it expresses no properly biological fact, but also holds that it is not identical to any physical fact. It might be hoped that this brand of conciliatory irrealism would offer the nonreductivist a plausible way out of the problem discussed in this chapter. This hope is forlorn, however. See §YYYYY below for discussion.

Nonreductivism (1) expresses a properly biological fact that is grounded in some congeries of purely physical facts.

Dualism (1) expresses a properly biological fact that is not grounded in any congeries of purely physical facts.

Straightforward eliminativism is implausible on its face. Also, as I have emphasized (Ch. XXXXX, §YYYYYY), the scientific successes of the last 400 years or so make dualism a dead letter. Though in Ch. XXXXX, I played along with reductivism, there are grounds for doubt about its ability to propoerly accommodate the data of multiple realizability; see Ch. XXXXX, §YYYYYYY (**??**). If these doubts are vindicated, nonreductivism is the most plausible view. Nonreductivism, however, faces a serious challenge.

The challenge stems from an unacceptable consequence of a constraint governing grounding explanations, which I will call the *determination constraint*. Before motivating and stating the determination constraint, however, it will be useful to set out, in some detail and with respect to a particular example, some apparent commitments of nonreductivism that are also involved in posing the challenge.

1 Standard Nonreductivism

Nonreductivism about the relationship between the biological facts and the physical facts holds that some biological facts are distinct from any physical facts, but are, nonetheless, grounded in congeries of physical facts. On a development of the view which I will call *standard nonreductivism*, there are properly biological facts that involve *properly biological entities*: entities that are involved in biological facts, but are not identical to any physical entity.[4] Consider, for instance, the fact expressed by

(1) Metabolism occurs in the cells of living organisms.

Let's suppose that this fact is, by the nonreductivist's lights, a properly biological fact. The standard nonreductivist holds that the fact expressed by (1)

[4]To provide an operationalist regimentation of the idea that a fact involves an entity, we need an operator, 'its being the case that ϕ involves τ', which takes a sentence ϕ in its first place and a term τ in its second place. A model for such an operator is the Finean operator for essence $\Box_\tau\phi$.

involves a kind of biological process, metabolism (and, presumably, the property *occurring in the cells of living organisms*). If metabolism (along with *being alive*, *etc.*) were identical to some physical entity then the fact expressed by (1) would turn out to be a physical fact after all. So, the standard nonreductivist concludes, metabolism will turn out to be a properly biological entity, distinct from any physical entity.

The claim that metabolism – a certain kind of biological process – is not identical to any physical process is plausible, on the assumption that multiple realizability arguments of the sort discussed in Ch. XXXXXX are sound. Consider a possibility of the sort required by the modal premise of a multiple realizability argument for the distinctness of the fact expressed by (1) from any physical fact: it is possible that metabolism occur even though none of the physical processes by which metabolism actually proceeds – certain undulations of the wave function, perhaps – occur. For instance, it is possible that metabolism occur in a situation governed by a thoroughly alien physics, in which living things are made of homeomerous material substances. Since metabolism occurs in such a situation, but no process characteristic of actual physical reality occurs, metabolism is not to be identified with any such physical process. At least, that is the conclusion to draw if one thinks the original multiple realizability argument is sound. So, the first claim characteristic of standard nonreductivism, that metabolism is a properly biological process, is motivated by the very same considerations that motivate nonreductivism.

As we saw in Ch. XXXXXX, it is consistent with a certain fact's involving metabolism *on one analysis* that it fail to involve metabolism at all on another analysis. What's more, any fact involving metabolism on one analysis, including the fact expressed by (1), may, for all we've said, involve completely different entities *on another analysis*. The alternative analysis may be one on which the entities in question are all purely physical.[5] The second claim characteristic of standard nonreductivism is that the hypothesis that (1) has multiple analyses is not true: (1) is uniquely analyzable as the possession by a certain kind of process, metabolism, of a property of such processes, *occurring in the cells of*

[5]If there are facts that involve no entities whatsoever (other than themselves), then a fact may vacuously involve only physical entities without itself being physical. So, for instance, it might be held that the fact expressed by 'it is raining' involves no entities at all (other than itself), but that a multiple realizability argument establishes that it is not physical.

living organisms.[6]

The more general possibility of multiply analyzable facts has another upshot for standard nonreductivism. From the premise that metabolism is distinct from any physical entity, it does not follow that any fact involving metabolism is a properly biological fact. Generic nonreductivism says that (1) expresses a properly biological fact, but we've implied nothing about which other facts are properly biological. In particular, it does not follow from the fact that (1) expresses a properly biological fact that every fact involving metabolism is a properly biological fact. So, for all we've said, it may still be that every ground for (1) contains at least one fact that (on one analysis) involves metabolism or other properly biological entities. (Convincing, or even minimally plausible, examples are, I admit, difficult to come by.)

However, it is plausible to assume that any physical fact that involves metabolism is a high-level physical fact, grounded in some further physical facts that do not involve metabolism or any other properly biological entities, on any analysis. So, for instance, the fact that certain protons moved across a membrane, a fact partly in virtue of which metabolism occurred on a certain occasion, is presumably a fact that does not itself involve metabolism or other properly biological entities. The same goes for the other motions of particles, elctrochemical bonds, and the like, in virtue of which metabolism occurred in the cells of a living being on that occasion. It would seem, then, that, at some point, we will come to facts that ground the fact expressed by (1) that do not themselves involve metabolism or any other properly biological entities.[7] Standard nonreductivism takes this appearance at face value: (1) is grounded in some congeries of facts, none of which involve metabolism or any other properly biological entities.

[6] This is a bit of a simplification, since it is plausible to think that there are a number of alternative analyses of the fact expressed by (1) that appeal to related entities, as suggested by the following representations:

(2) ⟨metabolism, λx(*x occurs in the cells of living organisms*)⟩
⟨*being a living organism*, *lambdaF*(metabolism occurs in the cells of *F*'s)⟩
. . . .

None of these analyses will be ones on which the fact in question avoids the connection problem.

[7] The argument here presumes a generalization to the multi-grade case of transitivity for '$<$': If $\phi_0, \phi_1, \ldots \Gamma < \psi$ and $\Gamma_0 < \phi_0, \Gamma_1 < \phi_1, \ldots$, then $\Gamma_0, \Gamma_1, \ldots, \Gamma < \psi$. Following Fine [CITE!] let's call this principle CUT. Suppose $\phi_0, \phi_1, \ldots \Gamma$ state some facts that ground the fact stated by (1), and that ϕ_o, ϕ_1 state exactly the metabolism-involving facts among $\phi_0, \phi_1, \ldots \Gamma$. Then, the standard nonreductivist might plausibly contend, each ϕ_i is grounded in some facts stated by Γ_i which do not involve metabolism. By application of CUT, the fact stated by (1) is grounded in some congeries of facts that do not involve metabolism.

In summary, we can characterize (generic) nonreductivism as the connjunction of two theses concerning the fact expressed by (1), which in our example represents the class of properly biological facts:

Fact Autonomy The fact expressed by (1) is a properly biological fact.

Fact Determination The fact expressed by (1) is grounded in some congeries of properly physical facts.

FACT AUTONOMY is tantamount to the rejection of identity reduction, and FACT DETERMINATION expresses the idea that the biological fact expressed by (1) is not fundamental. Standard nonreductivism adds three theses concerning metabolism, which, in our example, is a representative member of the class of properly biological entities:

Fact Uniqueness The fact expressed by (1) is uniquely analysable as the possession of metabolism of the property *occurring in the cells of living organisms*.

Entity Autonomy Metabolism is a properly biological process.

Entity Determination The fact expressed by (1) is grounded in some congeries of physical facts that do not involve any properly biological entities.

The determination constraint, together with very minimal ancillary premises, appears to be inconsistent with the conjunction of these three claims. Let us turn, then, to the statement and motivation of the determination constraint.

2 The Determination Constraint

The determination constraint is a constraint on full grounding. It is motivated by a consideration of an important common feature of the practice of proposing and assessing grounding explanations.[8] Consider a proposal concerning what fully grounds the stability of a certain oxygen nucleus n:

[8] Recall (Ch. XXXXX, §YYYYYY) that I am artificially restricting the use of 'explanation' and related locutions to refer to the class of *sentences* of the form

(3) $\psi_0, \psi_1, \cdots < \phi$.

In this chapter, when characterizing the views of other people, I sometimes use 'explanation' and its cognates without this restriction. When I do so, I put 'explanation' or its variant in scare-quotes.

(4) n is stable in virtue of the fact that n is an oxygen nucleus.

(4) is false, since it does not adequately specify the full grounds for n's radioactivity. Its inadequacy follows from the fact that there are radioactive isotopes of oxygen, and so oxygen nuclei which are radioactive. Given the existence of radioactive isotopes of oxygen, n's stability is not dependent solely on and determined solely by the fact that it is an oxygen nucleus. Perhaps (4) is on the wrong track entirely, and n's being an oxygen nucleus is not even a partial ground of n's stability. Perhaps, instead, n's being an oxygen nucleus is part of the grounds, but needs supplementation with other facts to yield a full ground.

Here's an example of the latter sort of case. The mass of our nucleaus n is partly grounded in the fact that n contains eight protons. Consider a proposal concerning what fully grounds the mass of n:

(5) n has a mass of 15.994915u in virtue of the fact that n is a nucleus containing exactly eight protons.

(5), like (4), is false: there are nuclei which contain exactly eight protons but which have a different mass, because they contain fewer neutrons than n. But it is easy to see how to repair (5) by adding to the putative grounds:

(6) n has a mass of 15.994915u in virtue of the fact that n is a nucleus containing exactly eight protons and exactly eight neutrons.[9]

(6), unlike (5), is plausible. Cases in which the proposed full grounds are on the wrong track entirely are even easier to come by:

(7) n has a mass of 15.994915u in virtue of the fact that n is more than 1km distant from the Eiffel Tower.

(7)'s falsity is immediately apparent, but is implied nonetheless by the existence of individuals like the Sun, which are much more massive than 15.994915u and are more than 1km distant from the Eiffel Tower.

The grounding claims (4), (5), and (7) are each false. Their falsity is due to their failure to meet the determination constraint. It is useful in stating the constraint to distinguish the *explanans clauses* of a grounding explanation

[9] There is here a delicate question of whether the grounds should be a single fact expressed by a conjunction, as in (6), or, instead, only a pair of facts expressed, respectively, by the conjuncts. It is difficult to see how one might choose, or even whether such a choice is required. Nothing of interest concerning the problem at hand turns on this matter.

like (5) from its *explanandum clause*.[10] The *explanans clauses* of a grounding explanation of the form

(8) $\phi_0, \phi_1, ... < \psi$

are the sentences $\phi_0, \phi_1, \ldots$, and its *explanandum clause* is ψ. Each of (4), (5), and (7) concern a particular case. Thus, (5) concerns a particular nucleus n, which both contains eight protons and n has a mass of 15.994915u. Intuitively, the falsity of (5) is demonstrated by the existence of a case that is just like the case the proposed explanations concern so far as the *explanans* clause goes, but differs from that case so far as the *explanandum* clause goes. The case in question involves an unstable oxygen numcleus o that still contains eight protons. Call such a case a *confounding case* for a proposed grounding explanation. The determination constraint, then, says that a proposed grounding explanation is true only if there is no confounding case for it.

(4), like (5), fails this constraint: there are confounding cases involving radioactive oxygen nuclei. (7) also fails this constraint: the sun provides a confounding case in which something more than 1km distant from the Eiffel Tower lacks the requisite mass. These are all toy cases, designed to motivate the determination constraint and illustrate its import. But once the constraint has been articulated, even in this rough and ready way, it is easy to recognize its application across a wide range of serious inquiries into what grounds what.

In fact, we have already encountered a few cases. Chemists tell us that alcohol is miscible in water partly in virtue of containing an hydroxyl group. Why should we think that this is only part of the story? Because polyester contains an hydroxyl group, but is not miscible in water. That is, polyester provides a confounding case for the (false) grounding explanation

(9) ethyl alcohol contains an hydroxyl group < ethyl alcohol is miscible in water.

Similarly, the utilitarian's grounding explanation

(10) Oswald's assassination failed to maximize utility < Oswald's assassination was wrong

[10]The terms '*explanans*' and '*explanandum*' is used in the literature to refer to almost all of the wide variety of entities for which 'explanation' is also used. Just as I am reserving 'explanation' as a term for a certain kind of sentence, so am I reserving 'explanans clause' and 'explanandum clause' as terms for sentences.

is false if there are acts, perhaps including keeping a desert-island promise, which fail to maximize utility but are nevertheless not wrong. Such acts provide confounding cases for (10). By contrast, if A is a fluid that is hotter than B, then there are no confounding cases for a grounding explanation of the form

(11) A contains exactly particles $a_0, a_1, ..., a_i$, a_0 has kinetic energy of n_0 joules, a_1 has kinetic energy of n_1 joules, ..., B contains exactly particles $b_0, b_1, ..., b_j$, b_0 has kinetic energy of m_0 joules, b_1 has kinetic energy of m_1 joules, ... $<$ A is hotter than B

in which the *explanans* clauses are true. Any case involving two fluids containing exactly the same numbers of particles with exactly the same kinetic energies will be one in which the analogue of A in that case is hotter than the analogue of B.

More cases are easy to come by. Here are a couple that may be familiar.

1. **Zombie Arguments**: a prominent argument against physicalism in the philosophy of mind appeals to the alleged possibility of *zombies*: individuals indiscernible in every physical respect (including relational physical properties) from a given individual that are nonetheless psychologically discernible. So, a zombie case might be an individual who is physically just like Joe, but, unlike Joe, is not conscious.[11] If there are such cases, they present confounding cases for any grounding explanation of the form

   (12) Joe has physical properties $P_0, P1, \cdots <$ Joe is conscious.

   A zombie who is physically indiscernible from Joe has each of $P_0, P1, \ldots$ but is not conscious. Physicalists may dispute the claim that there really are such cases, but, as the determination constraint says, they cannot accept their existence and still sensibly maintain that some explanation of the form (12) is true.

2. **The grounding problem**: *pluralists* about material constitution hold that a statue *Goliath* and a lump of clay *Lumpl* may consist of just the same matter throughout the entirety of their existence, and yet differ in a variety of respects. So, for insance, pluralists standardly argue that Goliath and Lumpl are distinct on the basis of the fact that Lumpl, unlike

[11] [CITE!] Chalmers, Kripke.

Goliath, can survive being squashed into a ball. The *grounding problem* is an objection to this view. According to the objection, pluralists lack the resources to ground the alleged differences between Lumpl and Goliath. [CITE! Bennett, Olson, Baker, Zimmerman, Sider, me, ...] Consider a proposed explanation of the form

(13) Lumpl has microphysical properties $P_0, P1, \cdots <$ Lumpl can survive being squashed into a ball.

Given that Lumpl's ability to survive squashing is microphysically grounded, (13)'s falsity is attested by the existence of Goliath, which provides a confounding case. Goliath has all of the requisite microphysical properties, but (ellegedly) cannot survive squashing.

3. **Entangled states**: One of the most striking features of quantum mechanics is that there are systems that have what are known as *entangled states*. Such systems are *composite*, in the sense that they are naturally decomposable into more than one (proper) quantum **subsystem**. [CITE! Mintert, F. et al.: Basic Concepts of Entangled States. *Lect. Notes Phys.* 768, 61–86 (2009).] So, for instance, a composite system might be an array of ions, where each individual ion is a component subsystem. A composite system is in an *entangled state* iff its state is not a product state of the states of its subsystems.[12] When a composite system c is in its entangled state e, it does not have its quantum state in virtue of the states of its subsystems. That is, if the subsystems are $s_0, s_1, \ldots, s_n$, and $q_0, q_1, \ldots, q_n$ are (pure) quantum states of the subsystems, then no grounding explanation of the form

(14) s_0 is in q_0, s_1 is in q_1,...,s_n is in $q_n <$ c is in e

is true. The determination constraint specifies a reason for rejecting (14). THere is a nomologically possible situation in which s_0 is in q_0, s_1 is in q_1,..., and s_n is in q_n, but c is in the product state of $q_0, q_1, \ldots, q_n$, instead of e. Such a situation is a confounding case for (14).

As we saw in Ch. XXXXXX, the determination constraint is reflected by a sort of implicit generality in the explanatory stories that accompany grounding

[12]This is a specification of entanglement for a composite system whose component systems are in a pure state.

explanations. The goodness of an explanatory story is preserved under uniform substitution of singular terms. Thus, if

(15)
$$\frac{\text{Alcohol contains an hydroxyl group}\quad \mathfrak{D}}{\text{Alchohol is miscible in water}}$$

were, *per impossibile*, a good explanatory story, then

(16)
$$\frac{\text{Polyester contains an hydroxyl group}\quad \mathfrak{D}'}{\text{Polyester is miscible in water}}$$

(where $\mathfrak{D}'$ results from uniformly replacing occurrences of 'alcohol' by 'polyester') would also be good.

Our rough characterization of the determination constraint, that grounding explanations are true only if they have no confounding cases, is motivated by these reflections. They also suggest a clearer refinement of that rough statement. The refinement requires that there be a grounding explanation in which the facts expressed by the *explanans* and *explanandum* clauses are *perspicuously articulated* with respect to an analysis. A fact f is perspicuously articulated (collectively) by clauses $\phi_0, \phi_1, ...$ with respect to an analysis iff ϕ_i expresses f, for each i, and, for each individual f involves (under that analysis), there is exactly one term τ occuring in some ϕ_i that refers to that individual.[13] Intuitively, a perspicuous articulation of f names names: any individual involved in f is named in some ϕ_i which expresses f, and every such individual is referred to by exactly one name. Requiring perspicuous articulation of the facts in question requires more specificity than one sometimes encounters in discussions of how certain familiar facts are grounded. So, for instance, one sometimes encounters examples like

(17) t is a table in location l in virtue of the fact that certain bits of matter are arranged table-wise in l.

There are two bits of (practically indispensable) hand-waving here. The first bit substitutes the predicate 'arranged table-wise' for some hideously complicated specificaton of certain features of and relations among particles. The second bit

[13]To capture the idea of a set of perspicuously articulated clauses in an operationalist framework, we use our a factual equivalence operator '$\phi \approx \psi$' and our operator 'its being the case that ϕ involves τ'. Then $\phi_0, \phi_1, ...$ are (collectively) perspicuously articulated iff $\phi_i \approx \phi_j$ for every i, j, and, for every individual x s.t. 'ϕ_i involves x' is true, for any i, there is exactly one term τ occuring in some ϕ_j which refers to x.

of hand-waving substitutes 'certain bits of matter' for a long list of particular bitsof matter. The requirement of perspicuous articulation leaves the first bit of hand-waving in place, but requires the eliminability of the second bit of hand-waving. Similarly, the requirement of perspicous articulation will require that one be able to specifically specify the particles and kinetic energies involved in order to apply the determination constraint to

(18) A contains certain particles with certain kinetic energies, B contains certain particles with certain kinetic energies $< A$ is hotter than B.

Here, then, is an attempt at a clearer specification of the determination constraint:

DC if $\phi_0, \phi_, \cdots < \psi$ then $\forall x_0, x_1, \ldots (\Phi(x_0, x_1, \ldots) \Rightarrow \chi(x_0, x_1, \ldots))$

for some Φ and χ such that Φ is the conjunction of perspicuous articulations of the facts expressed by $\phi_0, \phi_1, ...$ (under some analysis), and χ perspicuously articulates the fact expressed by ψ, $\tau_0, \tau_1, \ldots$ are exactly the terms occurring in Φ or χ, and $\Phi(x_0, x_1, \ldots)$ and $\chi(x_0, x_1, \ldots)$ are the results of uniform substitution of x_i for τ_i (for all i) in Φ and χ, respectively.

The syntactic details of this articulation of DC are somewhat fussy. Here's a way to think of what DC says. Every proposed grounding explanation has an associated universal generalization, which results from a four-stage process:

1. Conjoin the *explanans* clauses into a grand conjunction Φ;
2. Form the material conditional whose antecedent is Φ and whose consequent is the *explanandum* clause ψ; and
3. Uniformly replace all of the terms by variables; and
4. Close the result by prefixing appropriate universal quantifier phrases.

DC says, roughly, that a grounding explanation is true only if its associated universal generalization is. It says, precisely, that a grounding explanation is true only if it has some perspicuous articulation whose associated universal generalization is true.

It should be reasonably clear why DC requires only that *some perspciuous articulation* of a proposed grounding explanation be associated with a true universal generalization. Suppose the *explanans* clauses for a proposed grounding

explanation are not perspicuously articulated. The associated universal generalization would then be be too strong. Consider the plausible grounding explanation

(6) n has a mass of 15.994915u in virtue of the fact that n is a nucleus containing exactly eight protons and exactly eight neutrons.

We might stipulate that EIGHT is an atomic sentence (and so contains no terms) that expresses the fact that n is a nucleus containing exactly eight protons and exactly eight neutrons. Consider

(19) EIGHT $<$ n has a mass of 15.994915u.

The universal generalization associated with (19) is

(20) $\forall x$(EIGHT$\Rightarrow$ x has a mass of 15.994915u).

This generalization is false, since EIGHT is true but there are individuals with masses that differ from 15.994915u. But (6) intuitively passes the determination constraint, so applying DC to (19) would yield a constraint that is too strong.

Similarly, there may be perspicious articulations of the facts expressed by the *explanans* and *explanandum* clauses of a grounding explanation that are not coordinated in the right way. So, for instance, it is plausible that

(21) Twain is American, Twain is an author $<$ Clemens is an American author

even though the associated universal generalization

(22) $\forall x \forall y$(x is American, x is an author $\Rightarrow$ y is an American author

is false. DC does not allow us to conclude the falsity of (21) from the falsity of (22). There are, obviously, perspicuous articulations of the facts in question which yield the grounding explanation

(23) Twain is American, Twain is an author $<$ Twain is an American author.

The universal generalization associated with this grounding explanation is true. It is easy to check that, on the plausible assumption that (4) and (6) perspicuously articulate the facts in question, application of DC does not yield the wrong results.

3 The connection problem

Consider again our candidate properly biological entity, the process of metabolism, and a candidate properly biological fact involving that entity:

(1) Metabolism occurs in the cells of living organisms.

The view of metabolism we are considering is a standard nonreductivist view, which endorses FACT UNIQUENESS ENTITY AUTONOMY, and ENTITY DETERMINATION. By FACT UNIQUENESS, metabolism is involved in the fact expressed by (1) on every analysis; by ENTITY AUTONOMY, metabolism is a properly biological process, distinct from any physical process; and, by ENTITY DETERMINATION (1) expresses a fact involving metabolism which is grounded in some congeries of facts that do not involve metabolism. Suppose for the sake of argument that these claims are correct. Let $\phi_0, \phi_1, \dots$ be arbitrary perspicious articulations of the grounds for that fact (on some analysis). ENTITY DETERMINATION requires the truth of some grounding explanation of the form

(24) $\phi_0, \phi_1, \cdots <$ metabolism occurs in the cells of living organisms.

Since neither metabolism nor any other properly biological entity is involved in any fact expressed by any ϕ_i, none of the terms occurring in any ϕ_i refer to those entities. Let $\tau_0, \tau_1, \dots$ be exactly the terms occurring in $\phi_0, \phi_1, \dots, \Phi(\tau_0, \tau_1, \dots)$ be the (perhaps infinitary) conjunction of the ϕ_i's, and $\Phi(x_0, x_1, \dots)$ be the result of uniform substitution of x_i for τ_i (for all i) in Φ. The term 'metabolism' occurs in (1), and so

(25) y occurs in the cells of living organisms

is the result of uniformly substituting 'y' for the only term occurring in (1). So, DC applies to yield

(26) $\forall x_0, x_1, \dots, y(\Phi(x_0, x_1, \dots) \Rightarrow y$ occurs in the cells of living organisms)

Since grounding is factive, $\Phi(\tau_0, \tau_1, \dots)$ is true, and so $\exists x_0, x_1, \dots \Phi(x_0, x_1, \dots)$ is too. Standard quantificational logic then entails

(27) $\forall y(y$ occurs in the cells of living organisms).

(27) is obviously and disastrously false, since there are things – rockfalls, thermonuclear explosions, world wars, *etc.* – that do not occur in the cells of living

organisms. Since $\phi_0, \phi_1, ...$ are arbitrary perspicuous articulations of the putative purely physical grounds for (1), the same result follows for any such perspicuous articulations. So, no claim of the form (24) specifying purely physical grounds for (1) meets the determination constraint, and ENTITY DETERMINATION is false.

How did we get stuck with (27)? The determination constraint is controversial, but let's assume it temporarily for expository purposes; we will consider objections to it in due course. The feature of (24) which causes the problem is that the *explanans* clauses of its relevant instances don't mention metabolism at all. For this reason, standard quantifier containment laws allow us to move the quantifier '$\forall y$' in (26) into the consequent of the embedded conditional. Intuitively, what's gone wrong is that, if we do not mention metabolism, we lack any specification of the *connection* between the facts expressed by the *explanans* clauses of (24) and any fact involving metabolism. I propose, then, to call this the *connection problem* for standard nonreductivism.

To put the problem in a nutshell, our constraints require, roughly, that the full grounds for any fact involving an individual contain some fact involving that individual. Standard nonreductivism holds that some fact involving metabolism is grounded in a congeries of facts that do not involve metabolism. So, standard nonreductivism is at odds with otherwise well-motivated constraints on grounding.

It might naturally be suggested that the contraint on true grounding explanations that causes trouble can be summarized with the slogan

> You've got to mention metabolism to explain the features of metabolism.

I would resist this summary, on two related grounds. First, as I have emphasized already [Ch. XXXXX, §YYYYY], the word 'explain' and its variants are used for a wide variety of things, including not just grounding explanations (a certain class of sentences), but also various speech acts subject to epistemic constraints. So, the slogan invites misunderstanding, since it may reasonably be interpreted in a way that does not express the relevant constraint. Second, for this reason, this way of stating the constraint may suggest that it is motivated somehow by those epistemic contraints on "explanation." So, for instance, the slogan might be thought to be motivated by the constraint that a full "explanation" of the fact expressed by

(1) Metabolism occurs in the cells of living organisms.

must render that fact *intelligible* to one's audience. Or it might be thought to be motivated by the idea that the grounds specified by some such "explanation" must be *manifestly relevant* to (1). Or, most strongly, the slogan might be thought to be motivated by the idea that some specification of the grounds for (1) must entail (1) *a priori* [CITE! Chalmers].

But the determination constraint is not motivated, at least explicitly, by any such epistemic condition. It is motivated, instead, by considerations concerning the truth conditions for grounding claims: grounding claims are false if there is a confounding case. It is also motivated by the plausibility of the idea that good explanatory arguments have a sort of implicit generality: the goodness of an explanatory story is preserved under uniform substitution of singular terms. These considerations are independent of the relevant claims concerning intelligibility, manifest relevance, or *a priori* entailment. While we are considering epistemic matters, it is also worth noting that the argument is *a posteriori*, since the falsity of (27) is, though thoroughly obvious, straightforwardly *a posteriori*.

It may be worth rehearsing how straightforward eliminativism, reductivism, and dualism avoid the connection problem. Straigthforward eliminativism denies

(1) Metabolism occurs in the cells of living organisms.

There is no fact to ground. Since grounding claims are factive, no grounding explanation of the form (24) is true, and the connection problem is avoided.

Reductivism rejects FACT AUTONOMY, holding that the fact stated by (1) is identical to some fact expressed by a truth of final physics. If so, then there is every reason to believe that some perspicuous articulation of the fact in question mentions only entities mentioned in some perspicuous articulation of the physical facts that ground it. Suppose, for instance, that (1) is identity reducible to

(28) $\exists x(Fx \wedge Gx)$

where (*i*) F is a purely physical predicate that applies to processes, specifies the physical role played by metabolism, and is obtained from the Ramsey sentence for final biology in the way sketched in Ch. XXXXXX, §YYYYY; and (*ii*) similar remarks apply to the relation between G and the physical role played

by *occurring in the cells of living organisms*. Let p be a purely physical process satisfying both F and G. The explanation

(29) $(Fp \wedge Gp) <$ metabolism occurs in the cells of living organisms

is plausible *modulo* our reductionist assumptions, and it passes the determination constraint. On those assumptions, the *explanandum* clause expresses a fact perspicuously articulated by (28). So, the proposed grounding explanation

(30) $(Fp \wedge Gp) < \exists x(Fx \wedge Gx)$

perspicuously articulates the facts in question (on one analysis). The universal generalization associated with 30 is

(31) $\forall y((Fy \wedge Gy) < \exists x(Fx \wedge Gx))$

which is not just true, but logically true. So, the determination constraint is met and the connection problem avoided by our reductionist.

The dualist accepts the truth of (1). This differentiates dualism from straightforward eliminativism. The dualist also rejects the truth of any grounding explanation of the form (24), where $\psi_0, \psi_1, ...$ are purely physical truths. This differentiates dualism from both reductivism and nonreductivism. Since no relevant grounding explanation of the form (24) is true, the failure of such explanations to meet the determination constraint poses no problem. In effect, the dualist is prepared to accept that metabolism is a fundamental, properly biological entity, and, thus, that final physics is not a complete specification of the facts in virtue of which biological phenomena occur.

4 Objections to the Determination Constraint

By far the most promising avenue of resistance to the connection problem for a nonreductivist is to reject the determination constraint. There are a number of proposals in the literature to do so.

4.1 Enabling conditions

Dancy, for instance, [CITE!] has argued that, when it comes to grounding ethical phenomena, the determination constraint is too strong. For instance, he claims that a claim of the form may be

(32) Oswald's act a was wrong in virtue of $\phi(a)$

may be true even though there are acts b, such that b is not wrong even though $\phi(b)$ is true. Dancy's view, of course, confronts the problem of accounting for the fact that the existence of such a case is clear evidence that the explanatory proposal does not specify the *full* grounds for the wrongness of Oswald's act. So, for instance, Dancy's view must confront the fact that the existence of confounding cases for

(10) Oswald's assassination failed to maximize utility < Oswald's assassination was wrong

would provide decisive reason to reject it. Dancy is aware of the challenge, and suggests that explanations of the form (32) have *enabling conditions* that need to be held constant when considering confounding cases for a proposed explanation.

The distinction between an explainer and an enabling condition is familiar from discussions of causation [CITE! Mackie]. In at least some contexts, there are causes of an event or circumstance whose causal relation to that circumstance relies on certain background conditions that are causally relevant to the effect but not generally reckoned to themselves be among its causes. So, for instance, the striking of a certain match causes the match to burn a moment later. But it does so only under the condition that there is no 150 mph wind blowing across the match at the moment of ignition. The absence of a 150 mph cross-breeze is plausibly a condition which enables the strike to cause the match to burn without itself causing the match to burn. For this reason, the failure of otherwise similar matches to burn after being struck in the presence of a 150 mph wind does not provide a reason to reject the causal claim

(33) The match's being struck made it burn a little while later.[14]

The question of whether this distinction between causes and enabling conditions can sensibly be maintained is a matter of controversy. It would seem, however, that reasons to affirm or reject the existence of such a distinction in the causal case have analogues in the case of grounding explanations. Though I myself doubt whether the distinction can be sensibly maintained in either case,

[14] Here, obviously, I am using the "makes F" idiom to indicate causation rather than grounding.

there is no reason here to join the controversy. If we accept Dancy's distinction, there is a weakening of the determination constraint ready to hand: if an explanation of some ethical circumstance is true, then there is no case that is just like the case the explanation concerns so far as the *explanans* clause goes, differs from that case so far as the *explanandum* clause goes, and in which the enabling conditions are true. Call such a case a *super-confounding case*. A rough statement of the weakening of the determination constraint suggested by Dancy's view is that a proposed grounding explanation is true only if there is no super-confounding case for it. The putative confounding cases for

(10) Oswald's assassination failed to maximize utility < Oswald's assassination was wrong

familiar from the literature, Dancy might maintain, are also putative super-confounding cases. Moreover, Dancy's view suggests a new way in which (10) might be defended: argue that the cases in question are possible, but that they differ from the case of Oswald's act in that some enabling condition fails to obtain. (To be clear, Dancy himself is no utilitarian and does not accept (10).)

Dancy's view suggests that explanatory proposals are most perspicuously stated in the form

(34) $\chi : \phi_0, \phi_1, \cdots < \psi$

where χ states the enabling condition for the ϕ_i's to (collectively) make ψ the case.[15] Given an expression of a grounding explanation and its enabling conditions of this form, it is easy to weaken DC to accommodate Dancy's view:

DC+E if $Chi : \Gamma < \psi$ then $\forall x_0, x_1, \ldots (\Phi(x_0, x_1, \ldots) \Rightarrow \chi(x_0, x_1, \ldots))$

for some Φ and χ such that Φ is the conjunction of perspicuous articulations of the facts expressed by $\phi_0, \phi_1, ...$ and χ (under some analysis), χ perspicuously articulates the fact expressed by ψ, $\tau_0, \tau_1, \ldots$ are exactly the terms occurring in Φ or χ, and $\Phi(x_0, x_1, \ldots)$ and $\chi(x_0, x_1, \ldots)$ are the results of uniform substitution of x_i for τ_i (for all i) in Φ and χ, respectively. Intuitively, we just throw the enabling condition into the antecedent of the universal generalization associated with the grounding explanation. DC+E says that a grounding explanation is true only if there is some perspicuous articulation of that grounding

[15] We briefly encountered the idea of grounding *under a condition* and the concomitant notation in Ch. XXXXX, §YYYYY. I borrow both from Fine and Bader [CITE!].

explanation and its enabling condition whose associated universal generalization (with the enabling condition thrown in) is true.[16]

The connection problem purported to show that any supposedly non-fundamental entity, including a biological process like metabolism, is ineliminable, in the sense that each fact involving it is either fundamental or is grounded in some further fact also involving it. DC+E does not entail this result, since the relevant fact involving metabolism required by DC+E might be an enabling condition, rather than a ground. The response to the connection problem suggested by Dancy's view, then, is that, in every case that appears to give rise to the connection problem, the fact needed to properly connect the putative grounds to the putative grounded fact is an enabling condition, rather than another ground. So, the argument does not establish that entity in question is ineliminable.

It is not plausible, however, to contend that enabling conditions are needed in every case. For instance, in the toy cases we have considered, there is no need for enabling conditions.

(4) n is stable in virtue of the fact that n is an oxygen nucleus.

is plainly false, and its falsity is manifest given the confounding cases. A defense of (4) on the grounds that, in those confounding cases, some enabling condition fails to obtain lacks plausibility. Similarly, in the more serious cases posed by the grounding problem, zombie arguments, and quantum entanglement, the invocation of enabling conditions does not seem at all relevant. Lastly, no enabling condition seems necessary in the case of

(6) n has a mass of 15.994915u in virtue of the fact that n is a nucleus containing exactly eight protons and exactly eight neutrons.

Perhaps the ethical case (and maybe some other cases) are special in this regard. If so, then there is no barrier to claiming that enabling conditions are necessary in general, but that, in the non-ethical cases we have considered, the enabling conditions are null. But we have no reason to expect that the cases

[16]It might be held that χ is an enabling condition for the original grounding claim only when some *further* enabling condition χ_1 is in place. If so, DC+E is still too strong. But we could weaken DC+E further by letting Φ include both enabling conditions. It might be further held, however, that the phenomenon iterates: there are enabling conditions χ_2 for chi_1 to enable χ to enable the original grounding claim. If so, let $\chi_{\aleph_\alpha}$ be the conjunction of all members of the iterative tower of enabling conditions, and reformulate DC+E in the obvious way. Finally, it might be held that the iterative tower of enabling conditions has no bound (finite or transfinite), and thus that there is no such conjunction. This view lacks plausibility. Thanks to Selim Berker for discussion.

of the grounding of facts involving, *e.g.*, metabolism are going to be cases in which the enabling condition is non-null. In fact, given that our paradigm case, the biological process of metabolism, involves a natural process rather than an ethical phenomenon, we should expect that case to behave like the paradigms of null enabling conditions rather than like the ethical cases Dancy has in mind. Clearly, if the enabling condition is null in a given case, then DC+E and DC impose the very same requirements, so the connection problem still arises.

Suppose, however, that in every case in which some irreducible fact involving some properly biological entity e is grounded, the enabling condition is non-null and involves e. It is difficult to see how the resulting view is much of an improvement on accepting the conclusion of the connection problem. Some e-involving fact f is an enabling condition for the certain purely physical facts to ground some (other) e-involving fact g. So, g's dependence on and determination by those purely physical facts itself depends on f. Thus, those purely physical facts are not themselves the full story about what g depends on and how it is determined. To get a full story, we must add f, which is itself an e-involving fact. More generally, no story about what the existence and features of e depend on and how they are determined is complete if e itself is not mentioned. This is just the sort of ineliminablity which motivates identifying such an entity as fundamental.

As I have just, in effect, noted, the assumption that the distinction between grounds and enabling conditions is cogent complicates our understanding of how grounding relates to fundamentality. In Ch. XXXXXX we ultimately endorsed Raven's [CITE!] proposal to explicate fundamentality for an entity like the process of metabolism in terms of ineliminability: e is fundamental iff there is no grounding tree for some fact involving e whose leaves do not themselves involve e. The invocation of enabling conditions requires a strengthening of this conception. An E-grounding tree for a chunky fact f is a tree which starts from f, contains branches from f to some facts in virtue of which f obtains together with their enabling condition g, branches from those facts to some further facts and enabling conditions in virtue of which they obtain, and so on. Then e is fundamental, on this revised conception, iff there is no E-grounding tree for some fact involving e whose leaves do not themselves involve e. Since, on our assumption of the cogency of the ground/enabling condition distinct, the E-grounding trees for a fact f, unlike the grounding trees, correspond to the

full story of what f depends on and how it is determined, they serve better to explicate the conception of fundamentality at issue.

4.2 Necessitation

It is worth emphasizing that the motivation for the determination constraint appears to support something much stronger than DC. Proposed grounding explanations are shown to be false by the actual existence of confounding cases, but possible cases appear to serve just as well. Thus, the cases which cause problems for the utilitarian explanation

(10) Oswald's assassination failed to maximize utility < Oswald's assassination was wrong

of the wrongness of Oswald's act are not actual cases. They are alleged to be possible, and, as we've seen, their possibility implies the falsity of 10. Likewise, even if, due to some highly unlikely statistical accident, there happen not to be any radioactive oxygen nuclei, the falsity of

(35) n is an oxygen nucleus < n is stable.

is attested by the fact that there might have been some. Similar remarks apply quite obviously to the possibilities contemplated by the zombie argument, the argument concerning quantum entanglement, and the other cases we have considered. Even non-actual confounding cases for a proposed explanation demonstrate its falsity.

Thus, these considerations support a strengthening of DC. The stronger principle is

DC$_\Box$ if $\phi_0, \phi_1, \cdots < \psi$ then $\Box\forall x_0, x_1, \ldots (\Phi(x_0, x_1, \ldots) \Rightarrow \chi(x_0, x_1, \ldots))$

for some Φ and χ which perspicuously articulate the facts in question in the way specified in DC. DC$_\Box$ is closely related to the idea that grounding entails necessitation:

NEC if $\phi_0, \phi_1, ... < \psi$, then $\Box(\Gamma \Rightarrow \psi)$.

where Γ is the conjunction of the ϕ_i's.[17] In fact, DC$_\Box$ entails NEC. The consequent of DC$_\Box$ entails

[17] I suppress any qualifications that might be required to account for the possibility that the entities involved not exist, occur, *etc.*

(36) $\Box(\Phi(\tau_0, \tau_1, \dots) \Rightarrow \chi(\tau_0, \tau_1, \dots))$

where $\tau_0, \tau_1, ...$ are exactly the terms occurring in the relevant instances of Φ and χ.[18] Moreover, $\Phi(\tau_0, \tau_1, ...)$ is the conjunction of perspicuous articulations of the facts expressed by the ϕ_i's and χ is a perspicuous articulation of the fact expressed by ψ. As we assumed in Ch. XXXXXX, §YYYYY, sentences express the same fact iff they are co-intensional. Since a perspicuous articulation of a fact expressed by any ϕ_i expresses the same fact as ϕ_i (and the same goes for ψ), we have

(37) $\Box(\Phi(\tau_0, \tau_1, ...) \Leftrightarrow \Gamma)$

and

(38) $\Box(\chi(\tau_0, \tau_1, ...) \Leftrightarrow \psi)$.

Standard modal logic allows us to substitute the right-hand sides of these necessitated conditionals for their left-hand-sides in (36). So the consequent of DC$_\Box$ entails (36), which, in its turn, entails the consequent of NEC

(39) $\Box(\Gamma \Rightarrow \psi)$.

So, NEC follow from DC$_\Box$.

This gives rise to an objection to DC$_\Box$ based on objections to NEC. Alex Skiles [CITE!], for instance, has argued that NEC faces counterexamples. Here's one such counterexample. Consider the swans of Switzerland. Each swan in Switzerland is white. Let $s_0, ...s_n$ be the swans in Switzerland. Skiles contends that

(40) s_0 is white, s_1 is white,... $<$ every swan in Switzerland is white [CITE!].

This explanation, together with the instance of NEC in question, yields

(41) $\Box(s_0$ is white, s_1 is white,... $<$ every swan in Switzerland is white$i$.

But, as is familiar from Russell's discussion of general facts [CITE! *The Philosophy of Logical Atomism*], (41) is false. It is possible that there be a black swan b imported to Switzerland, while each of $s_0, ..., s_n$ remains white. If (41) is true (and assuming that all of the relevant facts are perspicuously articulated in (40)), then the very same possibility is also have a counter-example to DC$_\Box$. For the possibility in question witnesses

[18] Here again, I suppress qualification that might be required to take account of non-existence of referents for the terms..

(42) $\Diamond(\exists x_0, ..., x_n, y(x_0$ is white,$\ldots, x_n$ is white$\vee$Some swan in y is not white)).

So, if Skiles is correct about the truth of (40), then the determination constraint is too strong.[19]

Unsurprisingly, DC$_\Box$ can be maintained by arguing that (40) is false, though, for each of the white swans, that swan's being white is a partial ground of the fact that each swan in Switzerland is white. The left-hand-side needs supplementation in order to yield a true full grounding explanation. One symptom of this fact is that there is a conflicting case. Another, related symptom is that one would expect the full grounds for the fact that each swan in Switzerland is white to involve Switzerland. But none of the facts expressed by the *explanans* clauses of (41) involve Switzerland at all (nor, for that matter, swanhood).

How should the *explanans* clauses of (40) be supplemented? It is both standard and natural to suggest that what's missing is a clause saying, in effect that $s_0, ...s_n$ are the swans in Switzerland [CITE! Russell, Armstrong]. Such a clause expresses what is called a *totality fact* [CITE! Armstrong*A World of States of Affairs*], since it says, in effect, that certain swans are the totality of Swiss swans. It is both standard and natural to object to this proposal that the totality fact is itself a generalization

(43) Every swan in Switzerland is either identical to s_0 or ... or identity to s_n

of just the sort to be grounded. Notice that the restriction on this generalization, 'swan in Switzerland', is the very same as the restriction on the *explanandum* clause of (40). So, if the fact expressed by (43) is to be grounded, then, unless we accept that it grounds itself, its grounds cannot include the totality fact. In fact, it is unclear how that totality fact may be grounded. Considerations of this sort led Russell [CITE!] to despair of showing how generalizations depend on and are determined by matters of particular fact.

Fortunately, the despair is unwarranted. As Fine [CITE! "Guide to Ground", §7] and Armstrong [CITE! *A World*, Ch. 13] have suggested, there is no reason

[19] Skiles discusses another example which he contends causes trouble for NEC, involving the grounding of the existence of a composite tuna sandwhich by its proper constituents. For technical reasons related to the caveat regarding non-existence in n.18, this counter-example to NEC is not also a counter-example to DC$_\Box$. The problem for DC$_\Box$ can, however, be rehabilitated with some extra assumptions. The discussion of the rehabilitated problem would take us far afield, however, and the responses to that problem are similar to the responses to the problem posed by (40). For dtailed discussion, see [CITE!] "No Free Lunch", "Getting Priority Straight."

to identify the totality fact, that $s_0, ...s_n$ are the swans in Switzerland, with the fact expressed by the generalization (43). It should be characterized instead as a distinct fact involving a certain relation among $s_0, ..., s_n$ and Switzerland. There is no question that there is such a relation and that $s_0, ..., s_n$ and Switzerland stand in it. Perhaps no such fact is expressed by any extant sentence of English, including the sentence I have used twice already for the purpose. If so, then we can simply invent the missing verbiage. Let $\mathfrak{T}$ express the relation in question. The fact is expressed by '$\mathfrak{T}(s_0, ...s_n$,Switzerland).' The proposal, then, is that (40) is false, but

(44) s_0 is white, ..., s_n is white,$\mathfrak{T}(s_0, ...s_n$,Switzerland) $<$ every swan in Switzerland is white

is true. Call this invocation of the fact that $\mathfrak{T}(s_0, ...s_n$,Switzerland), together with the claim that it is distinct from the fact expressed by the generalization (43) the *supplementation proposal*.

Skiles objects that the supplementation proposal is ad hoc, on two grounds. First, no similar supplementation is appropriate in the case of causation, which Skiles takes to be a model for grounding. So, for instance, the truth of

(33) The match's being struck made it burn a little while later

does not entail the impossibility of the match's being struck and yet it not burning later. Given such a possibility, it would be implausible to insist that the specification of the cause needs supplementation. Second, Skiles contends that the supplementation proposal has no independent support [CITE!, §4].

There is, however, independent motivation for the supplementation proposal. One source of motivation is peculiar to the case of the grounding of universal generalizations by appeal to a totality fact. The idea is that the standard clauses specifying truth conditions for complex sentences in first-order logic offer an intuitive guide to what grounds sentences of the relevant form. In particular, those clauses' specification of sufficient conditions for the truth of the complex sentence tells us which grounding explanations whose *explanandum* clauses have the relevant form will be true, given that the *explanandum* clauses are true. Thus, one reason to think that the fact stated by a true conjunction is grounded in the facts stated by its conjuncts is that the standard truth conditions for conjunctions say that the truth of the conjuncts suffices for the truth of the

conjunction.[20]

In the case of universal generalizations of the form $\forall x\phi$, those truth conditions are specified by appeal to the truth of instances of ϕ, together with a specification of the domain of quantification. In particular, if the domain of quantification is $\mathfrak{D}$, and the assignment of each member of $\mathfrak{D}$ to the variable x satisfies ϕ, then $\forall x\phi$ is true. So, the clause explicitly says that it is sufficient for the truth of the generalization that the domain includes certain things, and that each of those things is ϕ. It is natural to interpret this clause as specifying grounds in a way consistent with the supplementation proposal. On this interpretation, the totality fact $\mathfrak{T}(s_o, ..., s_n$,Switzerland) specifies the domain, and the facts s_o is white,...,s_n is white do the rest of the grounding work. Though this motivation does not entail the supplementation proposal, it illustrates its intuitive appeal in the case of generalizations. So, in this case at least, the supplementation proposal is not ad hoc.[21]

This first source of motivation for the supplementation proposal is peculiar to cases concerning the grounding of facts stated by universal generalizations. A second source of motivation for the supplementation proposal has broader applicability. This motivation simply appeals to the powerful intuitive support for the determination constraint. It is plausible that grounding explanations are false when there are confounding cases for them. $\text{DC}_\Box$ clarifies and systematizes the idea. As we have seen, $\text{DC}_\Box$ entails NEC in a broad class of cases, including this one.[22] Insofar as the supplementation proposal is required to defend the determination constraint in this case, it has independent support.

Skiles considers this source of support, arguing that any supplementation of the *explanans* clauses in (40) is not required for the truth of (40), but rather plays the role of displaying other "explanatory" virtues that (40) has. These virtues include (i) the stability of the explanation under a range of counterfac-

[20]The idea here is that the clauses specify grounds by appeal to what is explicitly sufficient for the truth of the relevant sentence. So, though one can extract from those clauses, *e.g.*, the conclusion that $(\phi \vee (\psi_1 \wedge \psi_2)), \neg\phi$ are (jointly) sufficient for $(\psi_1 \wedge \psi_2)$ is not taken on this view to motivate the corresponding grounding explanation. Qualification is required here to accommodate the view explored in Ch. XXXXX, on which certain conjunctions are metaphysically transparent. It is natural to accommodate the failure of grounding in this case by tying the clauses in the first instance to the goodness of an explanatory argument, and then applying the metaphysical transparency theory to yield

[21]Thanks to Cian Dorr and Brannon McDaniel for discussion of the supplementation proposal.

[22]I am again suppressing certain qualifications concerning the possibility that the entities involved fail to exist; see n.18.

tual variations; (*ii*) the relevance of the *explanans* clauses to the *explanandum* clause; (*iii*) the differentiation of the actual situation from certain situations in which the *explanandum* clause is false; and (*iv*) the subsumption of (40) under a systematic pattern of grounding explanations. But, Skiles argues, the fact that the supplementary information $\mathfrak{T}(s_o, ..., s_n$,Switzerland) displays the possession of these virtues by (40) does not entail that (40) is false [CITE!, §5.4].

I am sympathetic to this distinction between the truth conditions for grounding explanation and what is needed to display various of its "explanatory" virtues. In fact, in Ch. XXXXX, I invoked a similar distinction between the truth conditions for a grounding claim and what must be said (in a given context) to render the fact stated by its *explanandum* clause intelligible to one's audience. Still, I think this response mischaracterizes the intuitive support for the determination constraint. Intuitively, the possibility of radioactive oxygen nuclei entails that

(4) n is stable in virtue of the fact that n is an oxygen nucleus.

is false. Similarly, though it is controversial whether it really is possible for there to be non-utility-maximizing acts that are not wrong, it is and should be entirely uncontroversial that, if such acts are possible, then

(10) Oswald's assassination failed to maximize utility < Oswald's assassination was wrong

is false. The problem is not merely that (10) lacks one or more of the virtues we demand of grounding explanations. The problem, to emphasize the point, is that (10) is false. The dispute over (10) is not principally a dispute over whether it has any further virtues, including stability, relevance, *etc.* The dispute is over its truth. Similar remarks apply to all of the other examples that motivate the determination constraint. The possibility of a confounding cases entails the falsity of the corresponding grounding explanations.

The same considerations tell against Skiles's first reason for claiming that the supplementation proposal is ad hoc. Recall that that first reason was that causation manifestly does not entail the necessitation of effect by cause.[23] There is,

[23]It should be noted that the idea that causation entails necessitation, though ultimately wrong, is not wildly off the mark. Hume's claim that causation entails "necessary connection" was not entirely implausible, and the appeal of Mill's method of difference for discovering causal relations suggests something in the area is on track. [CITE!] More recent work on causation has attempted to cash out this idea in terms of *counterfactual determination*, rather than necessitation. [CITE! Hall, Woodward, etc.]

Skiles concludes, no independent reason to think that grounding, which seems to many [CITE!] akin to causation, entails necessitation. But notice that, by the same token, the analogue of the determination constraint for causation is not plausible. The possibility that the match be struck but not burn a little while later – due, say, to a 150 mph cross-breeze – does not entail the falsity of

(33) The match's being struck made it burn a little while later

This is a way in which grounding explanations differ from causal claims like (33).

These reflections suggest a way of accommodating the truth of

(41) $\Box$(s_0 is white, s_1 is white,... $<$ every swan in Switzerland is white$i$.

with the motivation for the determination constraint. The sort of case which illustrates the consistency of (33) with the possibility that the putative cause occur without the putative effect is just the sort of case which motivates disinguishing between causes and enabling conditions. As we saw in §4.1, it might be suggested that a similar disinction be drawn between grounds and enabling conditions. If so, the appropriate conclusion to draw is that DC$_\Box$ is to be rejected in favor of something along the lines of DC+E. As we saw in §4.1, such a view immediately encounters a problem of essentially the same character as the connection problem.

4.3 Complexes

A further class of proposed counter-examples to DC concerns how the existence and features of certain complex entities are grounded. There are two kinds of complexes commonly discussed in the grounding literature: *sets*, which are typically taken to be complexes somehow arising from their members; and *composite material objects* which are taken to be complexes somehow arising out of their proper parts. So, for instance, a commonplace example in the grounding literature holds that

(45) Socrates exists $<$ {Socrates} exists.[24]

[24]The inspiration for (45) is the claim in (**?**) that it is essential to {Socrates} but not Socrates that Socrates$\in$ {Socrates}. Partisans of the example say that related intuitions favor (45) [CITE!].

Another commonplace example concerns a kind of case already briefly mention in §2 above. The case concerns a certain table t, and holds that

(46) t exists in virtue of the table-wise arrangement of its parts.

As we saw above, (46) is practically indispensable shorthand for a proposal that specifically enumerates the bits of matter in question, and cashes out the placeholder 'table-wise arrangement' in terms of specific facts involving those bits of matter. It might be suggested that these claims provide counter-examples to DC. For expository purposes, lets suppose both grounding explanations meet the requirement of perspicuous articulation. Also, we assume that the facts expressed by the *explanandum* clauses of these explanations are not identity reducible to facts involving only the individuals mentioned only by the *explanans* clauses.

Strictly speaking, the claim is false. It might be held that the universal generalization associated with (45) is

(47) $\forall x \forall y (x \text{ exists} \Rightarrow y \text{ exists})$.

This generalization is true. Similarly, if $p_0, ..., p_n$ are the bits of matter in question, the universal generalization associated with the grounding explanation for which (46) is shorthand is relevantly similar to

(48) $\forall x_0, ..., x_n \forall y (x_0, ..., x_n \text{ are arranged table-wise} \Rightarrow y \text{ exists})$.

Again, this universal generalization is true.

Still, it is reasonable to think that DC is getting off on a technicality here, since it just so happens that each and every thing exists.[25] Rehabilitated versions of the counter-examples arises for explanations of existence like the ones under discussion; see n. 19. These rehabilitated versions involves a couple of additional assumptions. Fortunately, we don't have to go through that rehabilitation, since closely related examples do not get off on the technicality concerning existence. So,

(49) Socrates is a philosopher $<$ {Socrates} contains a philosopher

is just as plausible as (45). Similarly,

[25] Readers who entertain the idea that some things don't exist may not agree that the determination constraint is satisfied in these cases.

(50) t is in location L in virtue of its proper parts' being arranged table-wise in L

is just as plausible as (45) One might think that the relevant associated universal generalizations are

(51) $\forall x \forall y (x$ is a philosopher$\Rightarrow y$ contains a philosopher)

and

(52) $\forall x_0, ..., x_n \forall L \forall y (x_0, ..., x_n$ are arranged table-wise in $L \Rightarrow y$ is in $L)$.

Given that Socrates is a philosopher, it is easy to see that (51) is false, since the White House, *e.g.*, does not contain any philosopher. Similarly, assuming that $p_0, ..., p_n$ are arranged table-wise in L and the White House is not, (52) is false. The objector concludes that DC is too strong.

Even if one accepts (49) and (50), there is no immediate counter-example here. The two cases are slightly different, in part because it is obvious that (50) is not perspicuously articulated. Let's start, then, with (49). On the assumption that the facts in question are perspicuously articulated, the associated universal generalization is not (51), but the obvious truth

(53) $\forall x (x$ is a philosopher$\Rightarrow \{x\}$ contains a philosopher).

The objector will protest that (49) is misstated. What the objector actually has in mind is

(54) Socrates is a philosopher $< t$ contains a philosopher

where 't' is a name for {Socrates}. The clearly false claim (51) is the universal generalization associated with this explanation. The objector concludes again that DC is too strong.

This new version of the objection is unconvincing, in part because the alleged misstatement (49) is simply the canonical form of the example that receives such widespread endorsement. Though I have indicated some reservations about (45) and (49), I am happy to grant their truth for the purposes of discussion. But it is far from clear that the further claim (54) is true. (54) is the result of replacing the complex term '{Socrates}' with the name 't'. This sort of replacement does not generally preserve grounding relations. So, for instance, it is plausible to hold that

(55) 2 is uniquely a least prime, 2 is divisible by 2 < the least prime is divisible by 2

but

(56) 2 is uniquely a least prime, 2 is divisible by 2 < 2 is divisible by 2

is manifestly false. Perhaps (54) is an exception. But clearly an argument for (54) independent of the plausibility of (49) is now needed. Insofar as (54) seems initially plausible, we should worry that it borrows its plausibility from (49), which poses no challenge to DC.

Consider now the putative counter-example involving

(50) t is in location L in virtue of its proper parts' being arranged table-wise in L.

One striking feature of this claim is that it presupposes that the bits of matter in question are proper parts of t. Thus, when one comes to persipcuously articulating the proposed explanation, one faces a choice: one may either include the fact presupposed explicitly as part of the grounds, or one may omit that fact. Only if one makes the latter choice does one obtain a grounding explanation whose associated universal generalization is the falsity (52). But that grounding explanation clearly omits information conveyed by the informal expression (50). If we include the information, we get something close to

(57) $p_0, ..., p_n$ are arranged table-wise in L, $p_o, ..., p_n$ (collectively) compose $t < t$ is a table in L

whose associated universal generalization is the truth

(58) $\forall x_0, ..., x_n \forall L \forall y$($x_0, ..., x_n$ are arranged table-wise in L, $x_0, ..., x_n$ (collectively) compose $y \Rightarrow$ y is in L).

The presupposed composition fact provides the connection between *explanans* clauses and the *explanandum* clause which is missing from the alternative. As in the case of {Socrates}, we have one grounding explanation which might be thought to enjoy some plausibility but presents no problem for DC, and another grounding explanation whose plausibility is more dubious but which, if true, presents a problem. As in the case of {Socrates}, the more dubious grounding

explanation needs support, which it cannot obtain from the plausibility of (50).[26] In neither case, then, do we have a counter-example to DC.

Moreover, if we were attracted to the critics' grounding claims, we would be faced with a puzzle, rather than straightforward counter-examples. For DC offers a simple, systematic constraint which systematizes the problem with grounding explanations like

(4) n is stable in virtue of the fact that n is an oxygen nucleus.

As we have seen, a broad array of cases, including cases taken directly from first-order disputes over grounds, support DC. So, faced with the critics' putative counter-examples, we face the difficult question of what the critics' explanations have that these paradigmatically false explanations lack. In other words, we face the difficult question of how we might systematically weaken DC to allow that

(54) Socrates is a philosopher $<$ t contains a philosopher

is true while (4) is false. As we have seen before, this challenge may be met by weakening DC to DC+E, and claiming that the fact that t contains Socrates is reckoned an enabling condition for (43). Similarly, one might hold that the fact that certain bits of matter are proper parts of a table t is an enabling condition for the grounding claim suggested by

(50) t is in location L in virtue of its proper parts' being arranged table-wise in L.

Thus, the enabling condition for that grounding explanation is a metaphysical correlate of the linguistic presupposition of (50). But, as we have also seen, weakening DC to DC+E does not ultimately avoid the sort of problem raised by DC.

This is the key challenge presented by the connection problem: offer a systematic weakening of DC that captures the evident falsity of grounding explanations like (4) but does not give rise to the connection problem or a close cousin. Objections to DC, whether based on counter-examples or on more broadly theoretical considerations, are incomplete unless and until this challenge is met. Let's turn, then, to the question of how one might hope to do so.

[26]The point underscores the utility of regimenting grounding explanations using '$<$'. Informally specified claims like (50) or 'the existence of a set is grounded in the existence of its members' obscure crucial distinctions. The merits of an explanatory proposal are best appreciated when it is considered expicitly.

5 Alternatives to dc

It must be admitted that at least some of the putative confounding cases that give rise to the connection problem do not seem overwhelmingly worrisome. Consider again a grounding explanation of the form

(24) $\phi_0, \phi_1, \cdots <$ metabolism occurs in the cells of living organisms

where the ϕ_i's are persicuously articulated facts involving only purely physical entities. Situations just like the situation of metabolism and the physical entities mentioned by the ϕ_i's so far as the *explanans* clauses go, but in which the counterpart of metabolism does not occur in the cells of living creatures present confounding cases for (24). Such cases will be counter-examples to the associated universal generalization, which has the form

(26) $\forall x_0, x_1, \ldots, y(\Phi(x_0, x_1, \ldots) \Rightarrow y$ occurs in the cells of living organisms)

The confounding cases in question are actual: in the actual situation, certain physical entities denoted by $\tau_0, \tau_1, ...$ collectively have the features required by the ϕ_i's, but, *e.g.*, hot nuclear fusion does not occur in the cells of living organisms. It is, as I said, difficult to find such cases particularly worrisome on their face for the relevant instances of (24).

This suggests a fertile avenue of exploration for those of us who would like to solve the connection problem: discover what separates the putatively real confounding cases from the putatively spurious confounding cases we read off from DC. Supposing that the putatively real confounding cases, unlike the putatively spurious ones, meet some condition R, then we may qualify DC appropriately:

DC$^-$ if $\phi_0, \phi_, \cdots < \psi$ then $\forall x_0, x_1, \ldots (\Phi(x_0, x_1, \ldots) \wedge R(x_0, x_1, \ldots)) \Rightarrow \chi(x_0, x_1, \ldots))$

where $\Phi(x_0, x_1, \ldots)$ is specified as in the original DC, and $R(x_0, x_1, \ldots)$ says that $x_0, x_1, ...$ collectively meet the condition R.

Here's an intuitive way of appreciating the role that the condition R needs to play. Consider again the putatively spurious confounding cases for (24) that we read off from DC. In these cases, there are certain physical entities denoted by $\tau_0, \tau_1, ...$ that have the features required by the ϕ_i's. The putative confounding cases are actual ones, in which the physical entities collectively have those features, but, *e.g.*, hot nuclear fusion (unlike metabolism) does not occur in the cells of living organisms. One striking aspect of these cases is that the physical

entities in question seem to have nothing in particular to do with hot nuclear fusion, though, of course, they do have something to do with metabolism. Thus, the most plausible candidates for R concern ways of specifying how what the entities in a putative confounding case must have to do with one another for it to be a genuine confounding case.

This may help solve the connection problem. Consider again the relevant instances of

(24) $\phi_0, \phi_1, \cdots <$ metabolism occurs in the cells of living organisms.

In these instances, the ϕ_i's express facts involving only purely physical entities. Note that DC$^-$, like DC associates a universal generalization with each grounding explanation. In the case of (24), that universal generalization has the form

(59) $\forall x_0, x_1, \ldots, y(\Phi(x_0, x_1, \ldots) \wedge R(x_0, x_1, \ldots, y) \Rightarrow y$ occurs in the cells of living organisms).

So long as R says what the entities involved in the grounds have to do with metabolism, it will indicate some relation between those entities and metabolism. So, as the notation indicates, the variable 'y' will occur in $R(x_0, x_1, \ldots, y)$. Whatever its other faults may be, this universal generalization, unlike the universal generalization associated with (24) by DC, does not entail the disastrously false claim

(60) $\forall x_0, x_1, \ldots, y(\Phi(x_0, x_1, \ldots) \Rightarrow \forall y(y$ occurs in the cells of living organisms)).

The key, of course, is finding a plausible candidate for R that solves the connection problem. Unfortuantely, all of the most obvious candidates for R yield versions of DC$^-$ that are unacceptable.

The first suggestion is that, for a putative confounding case to be genuine, the entities $x_0, x_1, ...$ corresponding to the referents of $\tau_0, \tau_1, ...$ must include (proper or improper) *parts* of the referent of some of the terms in the *explanandum* clause of the grounding explanation. As we will see, the idea is best illustrated with the case of the putative explanation of the table t's being in location L. Consider, then,

(61) $p_0, ..., p_n$ are arranged table-wise in $L < t$ is a table in L.

The putatively spurious confounding cases for this explanation that we can read off DC include the actual cases in which $p_0, \ldots, p_n$ are arranged table-wise in L, but something y ($\neq t$) is not a table in L. So, for instance, one such case concerns the chair c on which I am presently perched. Since c is not a table at all, c is not a table in L. Our critic plausibly diagnoses a problem with this putative confounding case: $p_0, \ldots, p_n$ have nothing to do with c, since they are not parts of c. So, this putative confounding case is not genuine.

Unfortunately, this candidate for R is not plausibly a necessary condition for a putative confounding case to be genuine. Part of the problem concerns the application of the notion of parthood to the explanations at issue in the connection problem. So, for instance, the purely physical entities involved in the putative purely physical grounds for metabolism's occurring in the cells of living organisms are presumably such physical processes as the formation of covalent bonds, the transition of electrons to their ground states, the electromagnetic interactions of charged particles, *etc.* It is far from clear that these physical processes are parts, in the relevant sense, of the biological process of metabolism. If they are not, then there cannot be genuine confounding cases for any explanation of any feature of metabolism in terms of the existence and features of those purely physical entities: all putative confounding cases will be ones in which the purely physical entities in question fail to bear the parthood relation (our candidate for R) to metabolism. But this surely goes too far. Presumably, part of what distinguishes the relevant instance of (24) from other empircally plausible but ultimately false instances of (24) is that the latter encounter (genuine) confounding cases. So, for instance, if we were simply to take just one of the explanans clauses ϕ_i in the relevant instance of (24), then we would get an explanation of the form

(62) $\phi_i <$ metabolism occurs in the cells of living organisms.

This grounding explanation will encounter (genuine) confounding cases, assuming there is no one-fact ground for the occurrence of metabolism. But, if the purely physical entities involved in the fact expressed by ϕ_i are not parts of metabolism, the proposal at hand incorrectly classifies these confounding cases as spurious.

Suppose, however, that we could be brought to accept the idea that metabolism itself has purely physical parts, despite its obscurity. We still don't have a plausible necessary condition on a situation's constituting a genuine confounding

case for an explanation. We have seen that

(4) n is stable in virtue of the fact that n is an oxygen nucleus

encounters clear confounding cases, given the existence of unstable oxygen nuclei. DC$^-$ correctly characterizes the situation in which an oxygen nucleus u is unstable as a genuine confounding case, since u is an improper part of itself. But there are even less plausible explanations that have genuine confounding cases of just the same sort, but which clear the bar set by DC$^-$. Suppose n and n^* are both stable oxygen nuclei, and consider the transparently silly explanation

(63) n is stable in virtue of the fact that n^* is an oxygen nucleus.

This explanation encounters a clear confounding case in the actual situation, in which u is an unstable nucleus and n^* is an oxygen nucleus. This candidate for R, however, classifies this putative confounding case as non-genuine, since n^* is neither a proper nor an improper part of u. I conclude that any condition requiring parthood relations between entities involved in the facts expressed by the *explanans* clauses and the entity involved in the *explanandum* is not a plausible necessary condition on genuine confounding cases.

The explanation (63) is so implausible that it might be thought to have some other problem. That is, it might be suggested that the confounding cases in question are not genuine, but we may conclude that the explanation is false on other grounds. So, for instance, it might be proposed that the grounds for facts involving composite entities like n must involve (among other things) the parts of n. (63) is false because it does not say that the stability of n is grounded in any facts involving n's parts. The *explanans* clause, in effect, mentions the wrong nucleus.[27] Unfortunately, this constraint on the truth of explanations of facts involving composite entities is not plausible. There are facts involving composite entities that have grounds that involve neither those entities nor their parts. So, for instance, there is a ground for

(64) Either the weather is sunny or n is a stable nucleus

[27]This proposal is at odds with *priority monism*, the view that all facts involving concrete entities are either facts that involve no concrete entities other than the entirety of the concrete cosmos, or are grounded in some such fact [CITE! Schaffer]. Given that 'n is stable' states a fact involving a composite entity, that this fact does not involve the entirety of the concrete cosmos, and that the entirety of the concrete cosmos is not a part of n, priority monism requires that n's stability have a ground that does not involve any of its parts. I set to the side the question of how a priority monist might qualify the proposed constraint, since the constraint is in any case implausible.

that involves the weather, rather than n or any of its other parts.

The next suggestion suggestion is that, for a putative confounding case to be genuine, the putative grounds must include circumstances which are *intrinsically related* in a certain way to the fact expressed by the *explanandum* clause of the grounding explanation. Again, let's start with the case of the putative explanation of the table t's being in location L. The proposed grounding explanation is abbreviated by

(65) $p_0, ..., p_n$ are arranged table-wise in $L <$ t is a table in L.

Consider again the putative confounding case for this grounding explanation, the actual situation, in which those particles are arranged table-wise in L but the chair c on which I sit is not a table in L. The suggestion is that this case is not a genuine confounding case because *being such that the particles are so-arranged in* L is not an *intrinsic feature* of c.[28] Proposing confounding cases requires identifying a situation s, and mapping each of the entities involved in the putative grounds or the putatively grounded fact onto an entity in s. So, for instance, the genuine confounding case for

(4) n is stable in virtue of the fact that n is an oxygen nucleus

is a situation in which u is an unstable oxygen nucleus. The mapping here is trivial: n in the actual situation gets mapped onto u. Since, n gets mapped onto something which *is* an oxygen nucleus, but *isn't* stable, we get an apparent confounding case. The proposal on offer is that genuine confounding cases will be ones in which the *explanans* clauses express facts whose obtaining is an intrinsic feature (collectively) of the entities involved in the fact expressed by the *explanadum clause*. So, the apparent confounding case for (4), in which u is an unstable oxygen nucleus, is genuine on the assumption that u's being an oxygen nucleus is an intrinsic feature of u.

[28] One might object that this property is intrinsic to the location L, and so is intrinsic to both c and L, taken together, as the specification of the proposal in the main text below requires. If so, then the putative confounding case that gives rise to the connection problem is genuine on this proposal. But Sider [CITE!] has noted, in effect, that the table-wise arrangement of particles imposes requirements on the particles' surroundings. Suppose t was carved out of living rock, and that the sculptors' efforts did not derange the intrinsic features of L: they just cut the surrounding stone away. After it is carved, L is intrinsically just as it was before, but there was not table in L before, and so the particles in question were not arranged table-wise. These considerations also suggest, however, that the particles' table-wise arrangement in L is not an intrinsic feature of t either. I set this worry to the side, since the proposal is independently problematic.

This proposal shares all of the difficulties of the proposal concerning parts. First, it is not clear that the facts expressed in the putative purely physical grounds for metabolism's occurring in the cells of living organisms are intrinsically related, in the relevant sense, to metabolism. If they are not, then, as in the case of the parthood proposal, no putative confounding cases will be genuine. But, as before, this does not seem a sound basis on which to conclude that the relevant instance of (24) encounters no confounding cases.

Second, even if we could be convinced that the putative grounds according to (24) are facts whose obtaining is intrinsic to metabolism, there are other evidently genuine confounding cases which are misclassified as spurious by this proposal. It is easy to check, for instance, that the proposal will reckon the obvious confounding cases for

(63) n is stable in virtue of the fact that n^* is an oxygen nucleus.

as spurious. Again, one might hold that (63) runs afoul of a condition additional to the relevant instance of DC^-, which says, *e.g.*, that grounds for facts involving n^* must include facts whose obtaining is intrinsic to n^*. As before, this proposed additional condition is easily seen to be implausibly strong, on the basis of consideration of the very same cases.

Our survey of candidates for R falls far short of being exhaustive. Still, I think these reflections illustrate a general problem for the initially promising line of inquiry we have been exploring. Recall that what we have been seeking is a way of discerning genuine confounding cases from spurious confounding cases by apeal to the condition R. In particular, we are looking for a specification of what the entities in a putative confounding case must have to do with one another for it to be a genuine confounding case. However, as the case of

(64) Either the weather is sunny or n is a stable nucleus

shows, there is a large class of facts that involve an entity n which have grounds that have nothing in particular to do with n. The true grounding explanations for such facts, however, have false counterparts, whose falsity is attested by the existence of genuine confounding cases. So, for instance, as in the case of

(62) $\phi_i <$ metabolism occurs in the cells of living organisms

taking a proper subset of the grounds for the weather's being sunny will yield a grounding explanation for (64) which is false, and whose falsity is witnessed by

the existence of genuine confounding cases. So, in light of an appreciation of full range of cases of grounding claims, the strategy we have been pursuing in this section seems to be on the wrong track. It is implausible to require that genuine confounding cases for an explanation of a fact involving metabolism be ones in which the counterparts of the putative grounds have something interesting in particular to do with whatever entity we map metabolism onto in specifying the case.

6 Acccepting the conclusion

Suppose, then, that we accept the determination constraint. The other assumptions needed to generate the connection problem are pretty innocuous. The assumptions that

(1) Metabolism occurs in the cells of living organisms.

is true; that it expresses a fact distinct from any purely physical fact; that the fact it expresses is grounded in some congeries of purely physical facts; and that metabolism is a properly biological process, distinct from any purely physical process, are definitive of standard nonreductivism. The applications of the logical principles involved are not open to serious doubt. The claim that hot nuclear fusion does not occur in the cells of living organisms is about as well-confirmed an empirical fact as one could hope to find. Nonreductivism, then, faces a very serious problem. In a nutshell, the problem is that there is a tension between the two core claims of nonreductivism: that there are some facts and entities that are not (identity) reducible to any physical facts or entities, but that the existence and features of some such non-physical entities are purely physically grounded.

Shall we, then, accept that nonreductivism is false? That would be too hasty. Nonreductivism is an important and otherwise plausible view in many areas. Consider nonreductivism about biology. Accepting that this is false requires accepting some implausibility: either there are no biological truths, biology is not generally grounded in physical facts, or each biological fact is identical to some physical fact. The first, straightforwardly eliminativist alternative is the most implausible. The second, dualist alternative is, empirically speaking, a dead letter. The best alternative, then, is accepting the identity reducibility of

biology to physics. For my own part, however, I would be highly reluctant to sign on to identity reduction. Another idea is needed.

Fortunately, there is wiggle room. Accepting the argument entails accepting the falsity of what I have called *standard* nonreductivism. But there are other varieties of nonreductivism available. I will close by reviewing some of these varieties, and identifying some problems they face. My aim here is not to settle the question of which avenue of response a nonreductivist should take. Instead, I simply want to vindicate the idea that the connection problem poses a serious problem for the nonreductivist by tallying the costs of various ways of solving or avoiding it. Noreductivists and their opponents should take these reflections to be suggestions for further research. Each of the views I will sketch involves denying one or more of the claims characteristic of standard nonreductivism.

6.1 Deny FACT UNIQUENESS?

DC says that a grounding explanation is true only if there is at least one perspicuous articulation of the facts in question for which the associated universal generalization is true. If, as FACT UNIQUENESS says, (1) is the only perspicuous articulation of the fact that metabolism occurs in the cells of living organisms, then, as we have seen, the universal generalizations associated with the relevant grounding explanations are each disastrously false. But, if there is another perspicuous articulation of that fact – that is, if FACT UNIQUENESS fails – then perhaps the problem is avoided.[29] Here's a way of denying FACT UNIQUENESS that seems promising: claim that there is an alternative analysis of the fact that metabolism occurs in the cells of living organisms that involves no properly biological individuals whatsoever.

At first glance, it is not entirely obvious that there could be such an analysis. But it might be held that the fact expressed by (1) is perspicuously articulated on one analysis by quantifying over *events*, or dateable, *token processes*, and characterizing those events as being "metabolic," *i.e.*, instances of metabolism. So, for instance, (1) might be taken to express the same fact as

(66) Every metabolic event e occurs in the cells of living organisms.[30]

[29] Not every way of denying FACT UNIQUENESS helps; see n. 6.

[30] It might be held that this attempt at paraphrase misses the mark, since (1)'s truth tolerates atypical cases in which metabolism occurs outside the cells of living organisms. Perhaps, for instance, the digestion of insect bodies by carnivorous plants should be classified as a metabolic process, even though it occurs outside the body of the plant. If so, please take

The fact so-expressed, the view contends, does not (on the correlative analysis) involve any properly biological entity that we denote using the term "metabolism." The fact in question is nevertheless properly biological on this view, since it is identical to fact expressed by (1), which is properly biological according to the generic nonreductivist. A grounding explanation of the form

(67) $\phi_0, \phi_1, \cdots <$ every metabolic event e occurs in the cells of living organisms

has a truth of the form

(68) $\forall x_0, \forall x_1, \ldots (\Phi(x_0, x_1, \ldots) <$ every metabolic event e occurs in the cells of living organisms)

as its associated universal generalization. Thus, the fact expressed by (1) is perspicuously articulated on one analysis without the use of any terms whatsoever, and so the connection problem is avoided.

Because the connection problem is general, pursuing this suggestion across the board would require finding perspicuous articulations of every properly biological fact that avoid the problem. Given the soundness of multiple realizability arguments for FACT AUTONOMY, it is doubtful that this strategy will work in every case. The problem concerns facts involving particular, token *individuals* that, given the soundness of multiple realizability arguments, turn out to be properly biological. Consider, for instance, the particular instance t of a terminator gene, possessed by a particular corn plant. Then

(69) t makes the plant which has it sterile

expresses a fact involving t. The most promising analogue for this fact of the metabolism-free perspicuous articulation of (1) articulate the fact by a sentence of the form

(70) p makes the plant which has it sterile

where p is a name of some particular token physical state: say a particular configuration of the corn-plant's DNA. But there are apparent possibilities in which the corn plant starts out made of ordinary matter, but its DNA is slowly replaced by a mixture of infinitely divisible, homeomerous, elemental substances

the suggestion in the main text as an illustrative simplification.

that play a similar causal role. In this "slow switch" scenario, (69) remains true through the replacement of the corn plant's DNA structure. By the late stages of the replacement, (70) is no longer true. If it is plausible to think that the scenarios involving alien physics figuring in multiple realizability arguments for FACT AUTONOMY are genuinely possible, then it is similarly plausible to think that this scenario is genuinely possible. Reasons for claiming that (69) is false in this scenario seem to have straightforward analogues for the original multiple realizability arguments, and the same considerations apply, *mutatis mutandis*, to reasons for denying the truth of (70). Denying that intensional equivalence is required for the identity reducibility of (69) to (70) seems to stand or fall with the proposal to deny that premise of the multiple realizability argument for FACT AUTONOMY. In short, the reasons for affirming FACT AUTONOMY seem to carry over straightforwardly to reasons for denying that (69) and (70) express the same fact.[31] The proposed reply to the connection problem in the case of (69) appears not to combine with FACT AUTONOMY to yield a stable position.[32] Hence, a challenge facing any nonstandard nonreductivist view of this sort is to say why multiple realizability arguments establishing the distinctness of metabolism from any physical process kind do not have analogues that establish the distinctness of token biological entities like t from any physical individual.

6.2 Deny ENTITY AUTONOMY?

Another line of response denies ENTITY AUTONOMY, the claim that metabolism is a properly biological process. Assuming that there is any such thing as metabolism, it is clearly a biological process involved, *e.g.*, in the fact expressed by (1). Is it a properly biological process, distinct from any physical process? On our assumptions, the answer is yes: given that metabolism is a biological process, any multiple realizability argument that establishes that (1) is a prop-

[31] The availability of analogues of multiple realizability arguments for token identity theses is discussed at length by Pereboom and Kornblith [CITE!].

[32] The nonreductivist might hope to avoid the connection problem posed by (69) by the same strategy applied to (1). The idea, taking a page from Quine [CITE!], is to claim that (69) is identity reducible to

(71) Every state s that is t-ish also makes the plant which has it sterile

where 'is t-ish' is a predicate in which the term t has no genuine occurrence. It is doubtful that this claim perspicuously articulates the fact in question on the relevant analysis, since *being t-ish*, *i.e.*, *being identical to t* involves t, and so the relevant analysis is still one on which the fact itself involves t.

erly biological fact, distinct from any physical fact, can be tweaked to yield an argument that establishes that metabolism is a properly biological process. Consider the sort of possibliities involving an alien physics appealed to by multiple realizability arguments of the sort we have been discussing. Those are also a possibilities in which metabolism occurs, but no actual physical process occurs. Assuming that identity with a process requires intensional equivalence, metabolism is distinct from any physical process. So, any nonreductivist who denies ENTITY AUTONOMY but accepts that there is any such thing as metabolism faces the challenge of saying why multiple realizability arguments that estabish FACT AUTONOMY do not have analogues that establish ENTITY AUTONOMY.

A different line of response simply rejects that there is any such thing as metabolism. This line is suggested by the history of discussion of nonreductive positions in the literature. *Property dualism* is a standard position in the philosophy of the special sciences. It claims that certain entities – property- and process-kinds – are properly biological entities, distinct from any physical property- or process-kinds, but that all of the individual bearers or members of those kinds are physical individuals [CITE!]. A property dualist might deny that there is any such thing as metabolism; there are only physical processes. But those physical processes are grouped into properly biological kinds, distinct from any physical kind. So, for instance, all of the metabolic processes e are physical, but they are grouped together under the properly biological kind *metabolic process*. Thus, the fact expressed by (1) is perspicuously articulated by something like

(66) Every metabolic event e occurs in the cells of living organisms.

It is doubtful that property dualism, understood in this standard way, ultimately evades the connection problem. If we accept that *metabolic process* is a properly biological property or kind, then there is little doubt that there is a fact f involving it which is intensionally equivalent to the fact expressed by (1). Perhaps such a fact f is expressed by

(72) The kind *metabolic process* is such that its members occur in the bodies of living organisms.

Now we can pose the connection problem by reference to f. As a matter of necessity, f obtains iff (1) is true. So, if multiple realizability arguments apply to (1) to distinguish the fact it expresses from any purely physical facts, then such

arguments also apply to f. If we are to accept the idea that all biological facts are physically grounded, then f is physically grounded. DC and the ancillary premises will then apply to f just as it did to proposals to physically ground the fact expressed by (1), yielding the false claim that every process-kind has members that occur in the bodies of living organisms. Thus, the connection problem is reinstated.

So, a better view affirms property dualism's negative half – that all individuals are physical – and denies its positive half – that there are properly biological properties or kinds.[33] That is, the better view holds that the only individuals and properties there are are physical individuals and properties, but that there are facts involving those individuals and properties which are distinct from any physical fact. An example of a properly biological fact is the one inaptly expressed by (1), and perspicuously articulated by (66). We might call this sort of view *predicate dualism*, to capture the idea that there are predicates like 'is a metabolic process' which are used to express properly biological facts, but which do not express properly biological properties.

It should now be clear that predicate dualism faces challenges similar to those faced by the nonreductivist who denies FACT UNIQUENESS. The problem concerns biological facts involving token biological states, like the fact expressed by

(69) t makes the plant which has it sterile

Applying the predicate dualist's solution to the connection problem in this case requires arguing either that the biological token state t is identical to some physical token state or that there is no such state. The first alternative faces the challenge posed by apparent analogues of the multiple realizability arguments that, by the nonreductivist's lights, establish FACT AUTONOMY. The second alternative, barring an analogue of straigthforward eliminativism which denies the truth of (69), requires that we find a way of making plausible the idea that the fact expressed by (69) does not involve t or any other properly biological token state.[34]

[33]It is unclear how plausible the denial of properly biological properties or kinds can be made, given that the higher-order claim

(73) $\exists F$(Every event e that is F occurs in the cells of living organisms.)

follows from (66).

[34]It might be thought that the conciliatory eliminativist view expored in Ch. XXXXX might help here. We could say, *e.g.*, that (69) appears to involve t, but that there is *really* any

6.3 Deny ENTITY DETERMINATION

The last line of response that maintains nonreductivism and evades the connection problem, is to deny ENTITY DETERMINATION. Recall that *entity determination* says that the fact expressed by

(1) Metabolism occurs in the cells of living organisms

is grounded in some congeries of physical facts, none of which involve metabolism or any other properly biological entity (on any analysis). Denying ENTITY DETERMINATION, then, requires that every congeries of facts that grounds (1) includes a fact that, on some analysis, involves some properly biological entity. To get a view that avoids the connection problem, that properly biological entity needs to be metabolism. By parity of reasoning, similar remarks will apply to facts involving digestion, excretion, reproduction, enzymes, epidemics, clades, and the other properly biological entities and processes.

It is worth dwelling on the import of this proposal. On this view, the facts expressed by final physics are still more fundamental than all of the other facts. Consequently, all of the properly biological facts, including the fact expressed by (1), are still grounded in physical facts. That's why the view maintains generic nonreductivism. Take, however, any congeries of physical facts that ground the fact expressed by (1). This congeries of physical facts might be, *e.g.*, a specification of the features of some entities of deep physics: quarks and leptons, the distribution of mass and energy across spacetime, or perhaps something even more unfamiliar. The view at hand requires that some fact among these somehow involves metabolism. Moreover, even if all such facts have grounds, some fact among those further grounds also involves metabolism.[35] Those metabolism-involving physical facts have a dual aspect. On one analysis, they

such thing as t. The problem with this suggestion is that DC seems to require that any ground for any facts involving t (on the *realist's* view) also involve t. Thus, mimicking the structure of grounding relations by a structure of grounding$^+$ relations requires facts involving t "all the way down." Ultimately, on the sparse grounder's view, the grounds$^+$ for any truth will include facts. So, the sparse grounder who wishes to use *grounds*$^+$ to mimic *grounds* faces the same difficult choices with respect to the facts that ground$^+$ (69) that the realist faces with respect to (69).

[35]The argument here deploys the CUT principle described in 7. Suppose $\phi_0, \phi_1, \ldots \Gamma$ is a ground for the fact expressed by (1), where each of the facts expressed by the ϕ_i's involves metabolism, and no fact expressed by Γ involves metabolism. Suppose $\Delta_0, \Delta_1, \ldots$ are grounds for each of $\phi_0, \phi_1, \ldots$, respectively. By CUT, $\Delta_0, \Delta_1, \ldots, \Gamma$ collectively express a ground for the fact expressed by (1). On the view we are discussing, there is a fact involving metabolism among this congeries of facts. By hypothesis, that fact is not expressed by Γ, so it must be among the facts expressed by the Δ_i's.

are facts of deep physics. But on another analysis they involve metabolism and so are also biological facts. It is appropriate to call this view *dual-aspect vitalism*. It holds that there is no level of physical organization below which metabolism is no longer involved. It's metabolism all the way down. Metabolism is a fundamental, biological process.[36]

I hope, by simply describing dual-aspect vitalism, to have illustrated its implausibility. It seems hardly more plausible than dualism. Again, another idea is needed.

6.4 Softening the blow

We have seen that the three ways of maintaining generic nonreductivism while denying standard nonreductivism each face challenges. The challenges have a common theme: though standard nonreductivism does not follow from generic nonreductivism, the motivations for generic nonreductivism seem also to motivate the further claims made by the standard nonreductivist. In particular, multiple realizability arguments appear to motivate FACT UNIQUENESS and ENTITY AUTONOMY, and the considerations telling against dualism seem also to motivate *entity determination*.

Another response to the connection problem is acceptance. On this response, nonreductivism in its full strength is false. But we can soften the blow by specifying an alternative view which salvages as much as possible of the nonreductivist's rejection of reductive and dualist views without running afoul of the connection problem.

This is the response offered by von Solodkoff [CITE!]. von Solodkoff contends that we should distinguish between a *full explanation* for a given fact and its *de facto explanation*. I have been using "explanation" throughout this chapter in a sense corresponding to full explanation, as a term for sentences expressing claims of full ground. von Solodkoff agrees that full explanations are governed by the determination constraint. *De facto* explanations are different. On von Solokoff's view, *de facto* explanations are not governed by the determination constraint. Moreover, von Solodkoff suggests, (1) has a *de facto* explanation whose *explanans* clauses express properly physical facts that involve neither

[36] Dual-aspect vitalism bears obvious similarities to certain interesting views in philosophy of mind, including panpsychist views on which every entity has properly psychological features [CITE! Chalmers, *The Conscious Mind*, pp. 152-5]. Tracing the similarities and differences between the views in question is beyond the scope of this chapter.

metabolism nor any other properly biological entity. Because, on her view, full explanations are governed by the determination constraint, she allows that the connection problem arises. So, on her view, any true full explanation for the fact expressed by (1) will have *explanans* clauses that express facts involving metabolism.

In fact, she suggests, a full explanation for (1) is yielded by adding to the *explanans* clauses of a *de facto* explanation certain *bridge principles* linking underlying processes explicitly to metabolism. So, grounds for the fact expressed by (1) will involve metabolism "all the way down." von Solodkoff attempts to soften the blow of this consequence, however, by contending that the *de facto* explanation of (1) exhausts the "distinctively metaphysical element" of the full explanation [CITE!] (p. 400). The bridge principles state facts that are among the grounds for the fact expressed by (1), but they aren't a *metaphysical* part of those grounds.[37]

von Solodkoff's strategy here is an example of a more general strategy. She attempts to soften the blow of the connection problem by contending that the existence of facts involving metabolism "all the way down" should not concern us. They have a character that somehow allows us to vindicate the spirit of nonreductivism, even if its dualist competitor turns out, strictly speaking, to be true. I very much hope she is right, but matters appear otherwise. What's distressing about accepting the conclusion of the argument for the connection problem is that metabolism-involving facts have to be among the grounds *at all*. Nonreductivism sensibly takes there to be a level of nature which is metabolism-free through and through. Accepting metabolism-involving facts among any full grounds for the biological facts means giving up this core commitment. The contention that such facts are not metaphysical seems to be no consolation whatsoever.

[37] I have simplified the exposition here in an important way. von Solodkoff shifts the discussion from explanantions whose *explanandum* clause is the non-linguitic truth 'metabolism occurs in the cells of living organisms' to explanations whose *explanandum* clause is

(74) 'Metabolism occurs in the cells of living creatures' is true.

She characterizes the bridge principles, following Williams and Rayo [CITE!], as specifying what is required for the truth of (1). The simplification is warranted because the connection problem concerns how to ground the fact expressed by (1). In any case, von Solodkoff is suggesting that the bridge principles state semantic facts regarding the links between the true sentence (1) and those aspects of representation-independent reality it concerns. In this sense, they are not metaphysical. von Solodkoff's appeal here to semantic ascent raises interesting issues that are beyond the scope of this chapter.

The theory of grounding brings the connection problem clearly into view. Like Kim's causal exclusion problem, it seems to call into question the cogency of nonreductivism [CITE!]. I think the connection problem is cleaner: it does not turn on messy questions concerning the causal closure of the physical, the nature and extent of causal overdetermination, the semantics of counterfactuals, and the like. But suppose I'm wrong about that, and the connection problem is just as messy. It is, clearly, a different problem.

Philosophers who sympathize with nonreductive views might think that the connection problem is a *reductio* of the application of the theory of grounding to explicate the idea of the layered conception of reality. This, I think, would be a mistake. The determination constraint is stated explicitly as a constraint on grounding explanations. But it is motivated by a central and widespread feature of debates over what depends on and is determined by what, in the relevant sense. So, it seems overwhelmingly likely that an analogue of the determination contraint will govern any replacement for grounding that might sensibly be proposed. Also, the cogency of multiple realizability arguments against identity reduction is a core commitment of nonreductivism. So, it seems overwhelmingly likely that an analogue of the connection problem will also arise for nonreductive views which eschew grounding.

As I have already indicated, it seems to me that dualism and straightforward eliminativism are off the table, at least in the philosophy of biology, geology, meteorology, economics, *etc.* If the connection problem cannot be solved, then one of the most striking applications of the theory of grounding is to support the reductive view that any fact that obtains solely in virtue of some congeries of physical facts is itself a physical fact. Perhaps the fact that identity reduction does not impugn the epistemic or methodological autonomy of the special sciences draws a little of the sting of this conclusion; see Ch. XXXXXX, §YYYYY. In any case, drawing the reductivist conclusion is premature at the present stage of inquiry, and I hold out hope that the connection problem can be solved. But we nonreductivists have our work cut out for us.