Winner of the 2015 Philosophy *prize essay competition*

A Vital Challenge to Materialism

JESSE M. MULDER

Abstract

Life poses a threat to materialism. To understand the phenomena of animate nature, we make use of a teleological form of explanation that is peculiar to biology, of explanations in terms of what I call the 'vital categories' – and this holds even for accounts of underlying physico-chemical 'mechanisms'. The materialist claims that this teleological form of explanation does not capture what is metaphysically fundamental, whereas her preferred physical form of explanation does. In this essay, I do three things. (1) I argue that the 'vital categories', such as *life form* and *life-process*, do not reduce to the 'physical categories' and show that there are no grounds for the materialist's metaphysically limiting claim; (2) I sketch a positive view on how vital and physical explanations can both apply to a given phenomenon, and on how they interrelate; and (3) I show that this view meshes nicely with evolutionary theory, despite being committed to a form of 'biological essentialism'.

Although it may seem slightly off-topic, let me start with a remark on the contemporary consciousness debate. In a recent overview of that debate, Josh Weisberg provides the following formulation of the problem of consciousness:

> One way to think of the problem of consciousness is via the question of how consciousness could just be a process like digestion …. These biological processes, though there are still some things we don't know about them, seem to fit right into the scientific view that everything happening in the universe is ultimately a process involving the basic forces of nuclear attraction, electromagnetism, and gravity, in various combinations. Digestion is a process by which food is broken down into usable energy for the body. This is a chemical process: complex starches, say, are converted into the glucose our cells need to power their activities. And the chemistry is explainable in terms of more basic atomic interactions: various attractions and repulsions at the atomic level make up chemical reactions. There's nothing else to them in the final analysis.[1]

[1] Josh Weisberg, *Consciousness* (Cambridge: Polity Press, 2014), 13.

doi:10.1017/S0031819116000024
First published online 10 February 2016

The picture Weisberg here sketches is common: perhaps consciousness poses a serious problem for materialism, but surely not biological phenomena generally, such as digestion. On his presentation, this thought actually turns out to shape the entire consciousness debate: either our attempts at reducing consciousness will succeed, just as in the case of life(!), or we're going to have to be dualists or panpsychists or mysterians or something such. The possibility that life may *by itself* pose a problem for materialism, and the ensuing interesting option of considering how the consciousness question plays out if this is indeed the case, is simply nonexistent in that debate.

But, I will argue, the common picture is wrong: life does pose a problem for materialism. And this insight may have far-reaching consequences – for instance for our understanding of consciousness.

What Weisberg writes is, on the face of it, entirely correct: of course digestion is a matter of processes that can all be understood chemically or even physically; it's all played out in combinations of 'the basic forces of nuclear attraction, electromagnetism, and gravity'. This is like saying that my copy of his book surely consists of ink patterns on paper, nothing more. This is perfectly compatible, however, with the equally obvious truth that my copy of the book *does* contain more than ink patterns on paper: it contains an overview of the consciousness debate. Likewise, those combinations of 'the basic forces' that make up a given episode of digestion are more than *just* that: as Weisberg himself says, they operate on 'food', which they convert into glucose that 'our cells need to power their activities'. These terms – 'food', 'cell', 'need', and the like – are alien to physics. The question is, of course, how these two levels of understanding – the physical, in terms of combinations of basic forces, and the biological, in teleological and functional terms, interrelate. I argue that the latter cannot be reduced to the former, and explain why this refutes materialism.

I will not try to be too specific about what materialism is. Weisberg's statement is a fine expression of the materialist's intuition. That intuition says that although we *seem* to understand biological phenomena in terms alien to physics, when it comes to the underlying reality, we have to resort to 'proper', that is, physical, explanations. Thus, on my understanding, the materialist takes physical forms of explanation to be capable of capturing what is metaphysically fundamental while denying biological forms of explanation this status.[2]

[2] See Jesse M. Mulder, 'The Essentialist Inference', *Australasian Journal of Philosophy* **91** (2013), 755–69, for a more detailed explication of this notion of fundamentality.

I proceed in three steps. First, I argue for the autonomy of the basic biological categories (§1). In this part, I rely heavily on Michael Thompson's thought-provoking work on this topic. Second, I sketch a non-reductive view on how they relate to the physical categories, drawing upon insights from the work of Elizabeth Anscombe (§2). And third, I reflect upon two seemingly powerful objections to my proposed understanding of life: one questioning its compatibility with evolutionary theory, another questioning its commitment to a form of 'biological essentialism', where I make thankful use of John Wilkins's work (§3).

1. What is Life?

If the materialist is correct, living organisms are nothing over and above enormously complex interactions of 'the basic physical forces'. It follows that they are, fundamentally, not different from other, non-living physical objects. They form a mere subclass of physical objects generally. Thus, the thought of providing a list of characteristics found only in living things, such as to single out that particular subclass, is a natural one. Especially if one faces opponents claiming that living phenomena require something beyond the purely physical – as the vitalists around 1900 did. Moritz Schlick, for instance, provided such a list in philosophical lectures of 1927 in the context of his discussion of the vitalist-mechanist debate.[3]

Now, typically, biology textbooks, as well as other introductory texts concerning the science of the living, begin by providing a version of such a list. Wikipedia's entry on life provides a fine example:

> Life is considered a characteristic distinguishing of something that exhibits all or most of the following traits: homeostasis,

[3] I owe this reference to Michael Thompson, *Life and Action* (Cambridge, MA: Harvard University Press, 2008), 4 (note 3). A translation of Schlick's list can be found in Moritz Schlick, *Philosophy of Nature* (New York: Philosophy Library, 1949), 73–4. Schlick says he got his list from Wilhelm Roux, the founder of 'developmental mechanics', who was deeply involved in the vitalist-mechanist debate around 1890. In those years, Roux's experimentally developed mechanistic theory of embryological development was refuted by experiments of Hans Driesch, who took his own results to support vitalism. See Reinhard Mocek, *Wilhelm Roux, Hans Driesch: zur Geschichte der Entwicklungsphysiologie der Tiere* (Jena: Fischer, 1974). I briefly look into the vitalist–mechanist debates in the next section.

https://doi.org/10.1017/S0031819116000024 Published online by Cambridge University Press

> organization, metabolism, growth, adaptation, response to stimuli, reproduction.[4]

One may read this list as expressing the kind of reductive attitude under consideration: life is a 'characteristic' of physical things more generally. For such a list to be successful, its elements must be comprehensible independently of life itself. But is this possible? Regarding lists that purport to serve such a reductive goal (explicitly or implicitly), Thompson writes:

> My suggestion will be that *every* candidate list-occupant must strike the sub-metaphysical Scylla of "DNA" or else sink into the tautological Charybdis of "organs".[5]

It will prove illuminating to see what Thompson means with the 'sub-metaphysical Scylla of "DNA"' and the 'tautological Charybdis of "organs"'. Consider the possible list-occupant 'Living things are highly organized' (a variant, indeed, on the mentioned 'enormous complexity'). Abstractly speaking, organization is not something one can measure on a scale of lower and higher degrees – 'Is the administration of the University of Pittsburgh more highly organized than, say, a Buick or the Hope diamond, or more complex than the rules of chess?', Thompson rightly wonders.[6] Abstractly speaking, then, the proposal at hand is empty. But perhaps sense can be made of it by supplying a relevant physical quantity – entropy, say. Surely, the configurations of matter constituting organisms exhibit lower entropy than most other configurations of matter. Of course, as Thompson remarks, fresh corpses are thereby not excluded – and if they are to be excluded, it becomes a mysterious question what entropic difference is required to distinguish between such corpses and their living counterparts. But even if, actually, all and only living things display entropic values below a certain threshold, nothing is gained by adding it as an entry to the envisaged list. After all, though unlikely, it is not physically *impossible* that arbitrarily low entropy values are occasionally reached in non-living systems. The problem, then, is that such a physical quantity *may* fail to coincide with the living, even if it *actually* does not. And this generalizes, of course, to proposals involving more than just the criterion of low entropy states. The point is, in the

[4] 'Life', in *Wikipedia*. See http://en.wikipedia.org/wiki/Life#Definitions. Retrieved December 16, 2015.

[5] Michael Thompson, *Life and Action* (Cambridge, MA: Harvard University Press, 2008), 39.

[6] Ibid., 36.

end, that extensional adequacy is simply not enough (otherwise a mere enumeration of all and only the living things across space and time would do the job, after all).

Consider, now, a much stronger suggestion: suppose that we find out that life is only possible when DNA is involved – in other words, that *no* combination of chemical substances that lacks DNA can constitute something that is alive. The requisite sort of 'organization' could then be cashed out very crisply in terms of containing DNA. Storrs McCall, for instance, writes:

> With DNA and protein-manufacture we have life: without them, merely physics and chemistry.[7]

Now, Thompson writes:

> The judgment about DNA, if it were true, would only show how resource-poor the physical world really is. It could make no contribution to the exposition of the concept of life … – except perhaps as pointing to a few gorillas and turnips might.[8]

And indeed, looking more closely at what McCall says, we find that he has something different in mind than merely the presence of DNA (and protein-manufacturing devices):

> [T]he division between living and non-living beings coincides with the introduction of informational software in the form of the genetic code. The hardware is the DNA and RNA molecules; the software is the encoded message they convey to the protein-making factories …. No coded informational software, no life.[9]

Surely, then, DNA plays a merely instrumental role in his definition of life. If no other kind of molecule was capable of embodying the relevant sort of code, then that indeed would merely show, as Thompson says, 'how resource-poor the physical world really is'.[10]

[7] Storrs McCall, 'The Origin of Life and the Definition of Life', 174. In Tuomas Tahko (ed.), *Contemporary Aristotelian Metaphysics* (Cambridge: Cambridge University Press, 2012), 174–86. McCall here follows Paul C. Davies, *The Fifth Miracle: The Search for the Origin and Meaning of Life* (New York: Simon & Schuster, 1999).

[8] Thompson, *Life and Action*, 37.

[9] McCall, 'The Origin of Life and the Definition of Life', 175.

[10] I should remark that both McCall and Davies in fact do not aim at a reductive understanding of life in life-less terms. Davies argues that there is 'downward causation' from the information encoded in the DNA to what happens physically, while McCall argues that, in addition, living things are governed by a special kind of analog information embodied in the

In the end, then, the problem is simply that DNA, or entropy, or any other purely physical quantity (or substance) is just that – something physical. What makes DNA, or entropy, special beyond what characterizes them physically (or chemically)? Of course, DNA and low entropy states play a special role *for living beings* – for example, the role of carrying information. That is why we may reasonably use the presence of such physical quantities and stuffs to indicate the presence of life. Epistemically, then, they may be highly relevant. But they are not metaphysically illuminating. Hence, as Thompson says, such putative list-occupants are 'sub-metaphysical', they do not serve their intended purpose of contributing to an understanding of what life is, metaphysically speaking.

On the other hand, there is of course a sense in which organization *is* central to life. The problem, however, is that spelling out this sense quickly leads us into a circle: organization is central to life only if it is understood as the type of organization that *living things* exhibit and use. Thompson writes with regard to such a conception of organization:

> [T]he relevant conception is simply equivalent to the idea of life: to be alive is to be *organ*-ized; to be alive is to be a subject of, say, 'vital organization'.[11]

And this, then, is the 'tautological Charybdis' into which putative list-occupants must sink if they escape from the sub-metaphysical Scylla.

Surveying other putative list-occupants, we arrive at similar conclusions. Take, for instance, 'metabolism', and 'responding to stimuli', which both occur in my Wikipedia-quote above.[12] Thompson writes:

> Are we to say, for example, that the asphalt on a summer day ''takes energy'' from sunlight, and ''converts'' it into heat? And is an avalanche, on the other hand, the ''response'' of a snow-covered hillside to the ''stimulus'' of, say, excessive yodeling?[13]

---

structure of space-time – '[w]herever life exists, spacetime is filled with smaller, more detailed dynamic patterns that govern growth and development' ('The Origin of Life and the Definition of Life', 181).

[11] Thompson, *Life and Action*, 38.

[12] 'Response to stimuli' should here not be understood in a behavioristic vein, but rather broadly so as to encompass also phenomena of vegetative life – a plant's responding to incoming sunlight by manifesting the process of photosynthesis, say.

[13] Thompson, *Life and Action*, 39.

Again, the point is that the relevant conceptions of metabolism and responding to stimuli are either not making the relevant difference (which is the case Thompson here highlights), or rather refer us back to life itself.

Now, there is of course nothing wrong with either sort of statement about life. Living things do take and convert energy in the merely physical sense, just as asphalt does. But they do so both in ways that have a place in their life cycle and in ways that don't (sub-metaphysical Scylla). Focusing on those energy-conversions that are of 'vital importance' leads to interesting insights in the relevant life form, but thereby we have already entered the domain of the living (tautological Charybdis).

The point can be brought out in a different way as follows:

> In a description of photosynthesis, for example, we read of one chemical process … followed by another, and then another. Having read along a bit with mounting enthusiasm, we can ask: ''And what happens next?'' If we are stuck with chemical and physical categories, the only answer will be: ''Well, it depends on whether an H-bomb goes off, or the temperature plummets toward absolute zero, or it all falls into a vat of sulfuric acid…'' That a certain enzyme will appear and split the latest chemical product into two is just one among many possibilities. Physics and chemistry, adequately developed, can tell you what happens in any of these circumstances – in *any* circumstance – but it seems that they cannot attach any sense to a question ''What happens next?'' *sans phrase*.[14]

That there *is* an answer to such 'what happens next'-questions, then, indicates a sense in which life-processes – the distinctive sorts of processes that living beings engage in – point beyond themselves. They are processes that exist for a reason, a reason that goes beyond their merely physico-chemical components or phases (recall Weisberg's observation that digestion is conversion of ingested food *in order to* power the activities of 'our cells').[15]

[14] Ibid., 41.

[15] Compare Sebastian Rödl, 'Infinite Explanation', *Philosophical Topics* **36** (2008), 123: 'We may think the following a prime example of a response to a stimulus: I clap my hands, and the cat shies away, hiding under the sofa. The following is just as good an example: I throw the cat into the fire, and she burns to ashes.' The first is a life-process: it is something that plays a certain role in a cat's life. The second is not: it is a purely physical process which the cat undergoes.

The search for a list of life, of the kind instanced by the quote from Wikipedia's 'Life' article, leads to the recognition that every single concept one might employ in its service turns out to already entail the very thing the list aims to capture: life itself. Organization, energy-conversion, responding to stimuli – all such concepts, *when used to characterize life*, form a kind of circle.[16]

There is, thus, a sense of the question 'why?' that is specific to biological phenomena. It asks for the point of, say, the occurrence of a given life-process, or the presence of a given organ. Where this question is applicable, we are dealing with living phenomena. The correct answer will relate the relevant phenomena to the *life form* in question. The life form encompasses the full developmental cycle of its instances; it constitutes their teleological unity. This is what a putative understanding of any biological phenomenon in purely physico-chemical terms simply leaves out. I will label these 'vital' notions – life form, life-process, organ, etc. – the *vital categories*.

Perhaps the materialist agrees: fine, she may say, these categories cannot be analyzed in purely physical terms – but, she will continue, that doesn't show anything about what is 'out there': it's still all nothing but combinations of the basic physical forces (to keep with Weisberg's way of putting things).

This is a typical move. The materialist says: 'Everything can be explained in physical terms'. Her opponent says: 'Look, you're wrong, there are things we understand in non-physical terms.' The materialist replies: 'Ah, but you see, that stuff you're talking about is not fundamental, only the bits of it that are amenable to physical explanation are.' Our question is, then, whether this metaphysical restriction to physical explanations (or, if you prefer, to physical phenomena) is acceptable or not.

The argument against this restriction is simple. From a neutral point of view, it is an evident fact that we use different forms of explanation in our understanding of different aspects of reality – the physical categories, the vital categories, and, arguably, others as well. We do occasionally discard one or another putative form of explanation – for instance, we have come to reject the magical forms of 'explanation' that gave rise to horrible witch hunts and burnings until deep into the 17th century in Europe. But notice that we *thereby* stopped thinking that there are such things – witches, magic – at all. So, on the face of it, we should expect that a rejection of the vital categories goes hand in hand with a denial that there is such

[16] For a discussion of putative list-occupants in much more detail than I can do in the context of this article, see Thompson, *Life and Action*, Part I.

a thing as life.[17] And that is, of course, absurd. But if we want to say that there are living beings, as I assume we want, then why should we accept the materialist's restriction to just physical explanation? Is it just because physical explanation has been so very successful? That is no argument: the success of one form of explanation is entirely compatible with there being multiple forms of explanation. Is it then, perhaps, because of the 'causal closure of the physical realm'? Well, if you believe in determinism, you will have to say, as I will argue below, that, indeed, the 'vital categories' do not capture anything real. There is no life in a deterministic world. But, then, determinism is surely not *constitutive* of the physical form of explanation (there is room for indeterministic physics), nor is it a settled *result* of contemporary physics.

These sketchy remarks are meant just to direct us to the core of the matter: if it turns out that the applicability of physical explanations *excludes* the applicability of teleological explanations, then the materialist has good reason for endorsing her restriction. However, the antecedent of this conditional is false. To see why, we need to outline a view on how these two forms of explanation interrelate.

2. The Physical and the Vital: a Unified Account

In a nutshell, the way to think about the relationship between vital and physical phenomena I recommend is the following. The matter out of which living beings are composed obeys the laws of physics. Living organisms use matter in order to maintain themselves; here it functions as *material* for their purposes (recall the information-carrying role of DNA). This requires that the laws governing the matter leave open various possibilities, allowing it be used in this or

[17] Barry Stroud makes an argument of roughly this shape against subjectivist theories of color. He writes: 'Prior acceptance of the exclusively scientific story of the physical world is what encouraged the idea of perceptions of color as nothing more than "sensations"' (*The Quest for Reality* (New York: Oxford University Press, 2000), 182). Here, the 'exclusively scientific story' corresponds to the restriction to physical forms of explanation that constitutes my target. By opposing such a 'negative metaphysical verdict' about color, Stroud is not arguing *for* the reality of color. This pessimistic outcome, however, is based on his understanding of the metaphysical 'quest for reality' (see also his *Engagement and Metaphysical Dissatisfaction* (New York: Oxford University Press, 2011)), which I think is mistaken. (See Jesse M. Mulder, *Conceptual Realism: The Structure of Metaphysical Thought* (Utrecht University: PhD Thesis, 2014), Chapter 1.)

that way, so that it can come to play its role within the teleological unity of one or another life form – all without breaking the laws governing it *qua* physical matter.

Elizabeth Anscombe has suggested this picture in the following passage:

> Let us pretend that Newton's laws were still to be accepted without qualification .... We could say: of course nothing violates ... the laws of the force of gravity. But animals, for example, run about the world in all sorts of paths and no path is dictated for them by those laws, as it is for planets. ... [T]he laws are, rather, like the rules of chess; the play is seldom determined, though nobody breaks the rules.[18]

Notice that my way of framing the question whether life poses a problem for materialism can be easily recognized in this quote. Anscombe in effect questions the materialist's restriction to just physical explanations, and suggests that there may be phenomena requiring a different sort of explanation without thereby contradicting the relevant physical explanations. Interestingly, she cites living beings (animals) as cases in point. If the physical laws are 'like the rules of chess', there is room for organisms to make their own chess moves without breaking those laws. That is to say, of course, that those physical laws are indeterministic.[19]

At this point, this may sound like traditional vitalism – which may appear to be a rather unattractive view if one reads Dennett:

> [V]italism ... [has] been relegated to the trash heap of history, along with alchemy and astrology. Unless you are also prepared to declare that the world is flat and the sun is a fiery chariot pulled by winged horses – unless, in other words, your defiance of modern science is quite complete – you won't find any place to stand and fight for these obsolete ideas.[20]

[18] G.E.M. Anscombe, 'Causality and Determination', 1972, in Anscombe, *Collected Philosophical Papers, Vol. 2* (Oxford: Wiley-Blackwell, 1981), 143.

[19] It would take us too far afield to explore how this point relates to the notorious controversy between compatibilists and libertarians in the free will debate. As in the case of consciousness, we have here another issue for which the metaphysical status of life may well be of crucial importance. (See Helen Steward, *A Metaphysics for Freedom* (Oxford: Oxford University Press, 2012) for a view that goes some way towards recognizing this point.)

[20] Daniel Dennett, *Kinds of Minds: Toward an Understanding of Consciousness* (New York: Basic Books, 1996), 24.

Dennett's thought is that if organisms influence what is going on in ways that go beyond what the physical laws governing their constitutive matter dictate, then surely there must be some extra force or stuff that produces this influence. And then the fact that empirical identification of this force or stuff consistently fails puts the vitalist position in a quite unfavorable light. Vitalism is relegated to the 'trash heap of history' by noticing that mechanistic descriptions of life-processes seem, at least on the chemical level, possible throughout.[21]

I don't want to enter into interpretive issues regarding traditional vitalism here; I'm interested merely in contrasting the anti-vitalist thought Dennett expresses with my own construal of how living beings manage to organize their constituent matter. Dennett's thought is a materialist one: if there were something special about life, it would have to be empirically discoverable as some kind of (quasi-)physical force or stuff. To see why this is a mistake, we now first need to consider the physical forces and stuffs, the physical forms of explanation, by themselves. I do so from a historical angle.

The rise of mechanistic thinking, originating in (or perhaps rather giving rise to) Early Modern thought, replaced the Aristotelian hylomorphism of the Scholastic era.[22] The baby that was poured out with the bathwater in this process is the Aristotelian notion of form. The

[21] Vitalism was largely abandoned on such grounds after the first few decades of the twentieth century, but it was still a live option in those early decades – see, e.g., Hans Driesch, *The History and Theory of Vitalism* (London: MacMillan & Co., 1914). However, Normandin and Wolfe's recent collection of articles on the history of vitalism over the past two centuries – *Vitalism and the Scientific Image in Post-Enlightenment Life Science, 1800–2010* (Dordrecht: Springer, 2013) – makes clear that Dennett is massively overstating his case. See, in particular, the contributions by Bechtel ('Addressing the Vitalist's Challenge to Mechanistic Science: Dynamic Mechanistic Explanation', ch. 14) and Turner ('Homeostasis and the Forgotten Vitalist Roots of Adaptation', ch. 11). The former, a dedicated 'mechanist', nevertheless urges that the vitalists were right in recognizing 'that the mechanist accounts [of their days] lacked the resources to account for some of the most fundamental features of living organisms' (346), and tries to amend his mechanistic views accordingly; the latter, a dedicated 'anti-mechanist', urges that '[d]efining a new metaphysics of biology will mean engaging with and incorporating long-shunned "vitalist" concepts' (287).

[22] It is impossible to do justice to the historical and philosophical subtleties of this shift in philosophical thought in the context of a systematically motivated essay. Robert Pasnau provides a thoughtful and very detailed analysis of the relevant metaphysical developments in his *Metaphysical Themes 1274–1671* (Oxford: Oxford University Press, 2011).

scholastics taught that the things inhabiting reality were comprised of matter and form: the form organizes the underlying matter in accord with its own principle or essence. Mechanistic thinkers rejected the notion of form: physical reality was thought to be comprised of matter alone.

Now, as I argue in more detail elsewhere,[23] this kind of thought rests on a mistake. Take, for instance, Descartes' fundamental notion of matter as defined by extension, and qualified by motion, size, and shape: this conception of matter, if correct, would capture the true nature of matter – its essence or form. A 'form-less matter' conception of reality is simply impossible: whatever we take reality to contain, fundamentally, we are bound to have corresponding forms. So, the shift was not one from hylomorphism to materialism (in the sense of form-less matter). Rather, the traditional forms with which the Scholastics worked, which defined such things as chairs, human beings, frogs, and trees, were replaced with such highly abstract (and often questionable) notions as Descartes' notion of matter. That is, the attempt to leave hylomorphism behind was in fact never completely successful. It remained in an almost unrecognizable way in the form of materialism: only those concepts that the new mechanistic physical sciences employed were taken metaphysically seriously.[24] The result was that all the traditional forms – including life forms – landed on the shelf labeled 'questionable metaphysical status'.

Now, modern physics is no different on this score: it too is committed to this residual hylomorphism. For suppose that electrons form a fundamental natural kind. Consider a particular electron: why does it move about as it does? Two answers can be given to this question. First, it *can move* as it does *because* that accords with its nature – for instance, with the fact that electrons are negatively charged, where such charge is understood as one of its constitutive powers. The 'because' here is not a causal one in the usual sense: adopting an explicitly Aristotelian label, we may call it *formal causation*. It determines

[23] See Mulder, 'The Essentialist Inference'.

[24] Fiona Ellis calls the confusion over the role concepts play in the understanding of reality, which made it seem as if hylomorphism was really rejected, 'the syndrome' (*Concepts and Reality in the History of Philosophy* (London: Routledge, 2005), 1). The skeptical extreme to which this syndrome may lead really does reject hylomorphism because it rejects the very idea that our concepts can capture fundamental aspects of reality at all. See Jesse M. Mulder, 'What Generates the Realism/Anti-Realism Dichotomy?', *Philosophica* **84** (2012), 49–80.

the possibilities for the electron, securing that it behaves in accord with its nature in all circumstances. Second, the electron *really moves* as it does because it has been shot into a cloud chamber in which a certain electromagnetic field is present. The 'because', in this case, *is* a causal one in the usual sense – in Aristotelian terms, it names an efficient cause. The formal cause determines *what* can happen, the efficient cause determines *that* something happens.[25]

Once we realize that mechanistic thinking requires such a notion of formal causation – why do the various components of any mechanism act and interact as they do? – we have made one crucial step towards understanding the way in which the realm of the living may influence what is going on, without requiring vital forces or stuffs of the type Dennett ridicules. For life forms under which living organisms fall operate just as natural kinds, such as that of our electron, do: by way of formal causation. Why are these complex starches being broken down? Because that is part of what digestion is for human beings. The 'because' again indicates formal causation. And, again, we may distinguish this sense of cause from the efficient cause (e.g., ingestion of the cheese sandwich housing those complex starches).

Of course, despite these similarities, formal causation by life forms differs fundamentally from formal causation by natural kinds. Life forms express themselves in the organization of underlying *matter*, which thus functions as *material* for the organism in question. Indeed, that is one crucial part of any living creature: incorporating material from its surroundings by way of teleological processes typical of its life form. Therefore, everything that happens inside an organism can *also* be investigated from a purely physical point of view. Failure to see this may make it seem as though successful physical explanation in a given case *replaces* biological explanation.

2.1 Emergentism and Downward Causation

How does my understanding of the relation between living organisms and their constitutive material relate to emergentism? Broad's original definition of that concept reads as follows:

[25] I do not intend to be faithfully representing Aristotle's doctrine of causes; my interests are systematic, not exegetical, and my use of Aristotelian labels is thus meant as expressing allegiance to a broader philosophical orientation, not to a specific metaphysical doctrine.

> Put in abstract terms the emergent theory asserts that there are certain wholes, composed (say) of constituents A, B, and C in relation R to each other; that all wholes composed of constituents of the same kind as A, B, and C in relations of the same kind as R have certain characteristic properties; that A, B, and C are capable of occurring in other kinds of complex where the relation is not the same kind as R; and that the characteristic properties of the whole R(A,B,C) cannot, even in theory, be deduced from the most complete knowledge of the properties of A, B, and C in isolation or in other wholes which are not of the form R(A,B,C).[26]

If one reads 'relation (of the same kind as) R' to mean 'life form', 'constituents A, B and C' to mean 'matter', and 'certain characteristic properties' to mean 'life-processes' and the like, this is in line with what I propose. For then the 'most complete knowledge of the properties of A, B, and C in isolation' will amount to physical knowledge, and from such knowledge it is indeed impossible, 'even in theory', to derive conclusions about living things.

Now, in the words of Powell and Dupré, this implies 'unpredictability in principle, … obstacles to prediction somehow inherent in the nature of things', which is 'often seen as philosophically mysterious'.[27] The unpredictability is, however, relative to physical forms of understanding. What is unpredictable physically speaking may very well be predictable biologically speaking.[28] Life is an emergent phenomenon not in the sense that it is completely inexplicable, but rather in the sense that its explication involves principles different from those governing the physical stuff it is made of.

To say that something is 'emergent' is, however, not very helpful for understanding how what emerges relates to what it emerges

[26] C.D. Broad, *The Mind and Its Place in Nature* (London: Routledge & Kegan Paul, 1925), 61.

[27] Alexander Powell and John Dupré, 'From Molecules to Systems: The Importance of Looking Both Ways', *Studies in History and Philosophy of Biological and Biomedical Sciences* **40** (2009), 59.

[28] Notice, though, that physical and biological prediction differ fundamentally. Biological prediction is susceptible to a special kind of failure, arising out of the peculiarity that living things may fail to achieve what they aim at. Given that horses are four-legged, for instance, one is perfectly safe to predict that this pregnant mare will give birth to a foal with four legs. If the foal turns out to have only three, there is a sense in which the prediction is *not* thwarted, for it is clear that something has gone *wrong* – the foal should have had four legs, for that is what suits horses. Nothing can go 'wrong' in this sense in inanimate nature.

from. Downward causation can be used to fill this gap. For instance, Dupré (a staunch opponent of reductionism) writes:

> Downward causation seems a very natural way to think of much of what I have been saying about molecular biology. What causes the human genome to behave in the particular ways it does – for example, various sequences being transcribed or not at varying rates, changes in conformation and spatial relation of chromosomes, and so on – is a variety of features dispersed over the surrounding parts of the cell. The behavior of the part is to be explained by appeal to features of the whole. …
>
> The cell, I think we must say, with all its intricate structure and diverse contents, is what causes these contents to behave in these life-sustaining ways.[29]

For Dupré, then, downward causation is causation that flows from the whole to the parts. Yet this does not really help, for how does such downward causation by 'the cell' work? With my notion of formal causation in hand, sense can be made of this idea: to say that 'the cell' organizes its underlying material is just to say that the relevant life form determines, by formal causation, which of the physical possibilities is realized, resulting in life-processes geared towards the full unfolding of the life form in question.[30]

My proposed understanding of the relation between biological and physical phenomena is thus thoroughly anti-reductionist in spirit. It refutes the idea that teleological explanation is incompatible with physical explanation: it shows that they are compatible, and that this does not require queer quasi-physical forces. Still, it is bound to invite difficult (skeptical) questions. Let us test my proposal by reflecting on two such questions: (1) a question concerning 'life-like'

[29] John Dupré, 'It Is Not Possible to Reduce Biological Explanations to Explanations in Chemistry and/or Physics', in Francisco Ayala and Robert Arp, *Contemporary Debates in Philosophy of Biology* (Malden, MA: Blackwell Publishing, 2010), 42–3.

[30] Dupré at times seems to come close to the kind of view I am proposing, yet he never really distinguishes between physical and vital forms of explanation. The result is that he can only express his anti-reductionism in mereological terms – that is, in terms of 'the whole' influencing 'the parts'. He frequently alludes to the importance of 'the wider context' for understanding biological phenomena, in particular on the molecular level, and is positively impressed by 'systems biology'. See the essays in his *Processes of Life: Essays in the Philosophy of Biology* (Oxford: Oxford University Press, 2012), and his 'Living Causes', *Aristotelian Society Supplementary Volume* **87** (2013), 19–37.

chemical processes, and (2) the worry that biological formal causation is incompatible with physical indeterminism, contrary to what I claim.

2.2 Life-Like Chemical Processes

Life-like chemical processes are processes that resemble life-processes in certain ways but occur outside of the realm of the living. If the vital categories were to apply also to such processes, it would seem that they fail to capture what is distinctive of life – in which case the skeptical thought that there is nothing 'distinctive' out there to capture looms large.

Take, for instance, a candle flame. It takes up underlying material (say, paraffin wax) by melting it, which allows it to travel up the wick by capillary action, where it evaporates and then burns, sustaining the flame itself. The flame also takes in oxygen in its (multistage) process of burning, and releases carbondioxyde and water. The flame, thus, seems to be a unity that takes up material from the environment, which it 'digests' in order to sustain its own existence.[31] So why is the flame not a living organism? The answer is plain: application of the vital categories is not warranted in this case; there is no teleological unity. The flame is a physical process that can be *completely* understood in terms of the powers of the objects and stuffs involved.

But isn't the difference between such a flame-process and, say, the life-process of digestion then not a mere difference in complexity? If so, organisms are nothing but very complex flames, so to speak.

I have already sketched, on a very abstract level, why this thought is untenable in §1 above. At this point, it will be helpful to look at a concrete example: protein synthesis. It shows a few interesting oddities that are absent in cases like our candle flame.

Part of the process of protein synthesis is *protein folding*, which proceeds by a complex, but relatively well-understood mechanism (though Dupré states that it is a 'major problem in molecular biology'[32]). The so-called translation process, guided by a ribosome,

[31] I ignore the fact that candles are artifacts, and thus involve the purposes of human beings. If you don't like the example, you could substitute Mount Wingen for it – the famous 'Burning Mountain' in New South Wales, Australia, where an underground coal seam fire has been going on for thousands of years.

[32] Dupré, 'It Is Not Possible to Reduce Biological Explanations to Explanations in Chemistry and/or Physics', 42.

produces a sequence of amino acids on the basis of a strand of mRNA which was transcribed from the DNA in the cell nucleus. The protein thus formed assumes the three-dimensional structure to which its particular chemical structure, together with the environmental conditions (such as pH, temperature, concentration of salts) gives rise. Special proteins called chaperones often catalyze that process. It may undergo further changes in order to attain the three-dimensional form on which its functionality depends. These changes include: forming specific internal bonds (disulfide bridges), cutting the chain at some point, removing certain amino acids from the end of the formed chain, fusing together various already folded proteins into a whole, and forming metal clusters.[33]

At all stages, the process of protein synthesis involves dedicated organelles, proteins, and other components – which is to say that there are *reasons* for them to be around during the process. The same cannot be said in the case of a flame that consumes some supporting material – the oxygen and the wax are not around *in order for* the burning process to take place.[34] Moreover, these organelles, proteins, and other components are themselves products of life-processes, involving, amongst other things, the process of protein synthesis itself.[35]

[33] See David Whitford, *Proteins: Structure and Function* (Chichester: Wiley, 2005), esp. chs 8 and 11. A good discussion of this example from a philosophical perspective can be found in §4.3 of Andreas Hüttemann, 'Comparing Part-Whole Reductive Explanations in Biology and Physics', in Dennis Dieks *et al*. (eds), *Explanation, Prediction, and Confirmation* (Dordrecht: Springer, 2011), 183–202. Relevant references to empirical studies of the process can be found there as well.

[34] Recall that I am ignoring the fact that candles are artifacts.

[35] A notorious case in point is the production of the relevant mRNA-strand, which codes for the protein that is to be produced. Since genes are often distributed over various parts of the total DNA, the transcribed RNA has to be 'spliced' at the proper places to remove the non-coding parts ('introns'), an activity carried out by what is called the spliceosome (Igor Rogozin *et al*., 'Origin and Evolution of Spliceosomal Introns', *Biology Direct* **7** (2012), 1–28, contains interesting observations on this peculiar entity). Another notorious case in point is the production of organelles. For instance, it is unclear for several kinds of organelles whether these can be produced from scratch in a cell, or rather require existing organelles to be copied from. See, e.g., George Mullins, *The Biogenesis of Cellular Organelles*, (Georgetown, Texas and New York: Landes Bioscience and Kluwer Academic, 2005).

The life-process of protein folding is thus embedded in a wider context of life-processes to which it is intimately and reciprocally connected. Again, this makes for a difference with the case of the flame. This point becomes especially vivid once we broaden our view and contemplate the fact that, as the case may be, the protein folding process we started with occurs because that specific protein is necessary for an immune response to a virus that has invaded the tissue within which the hosting cell is located. Again, nothing of this teleological sort is visible in the case of a flame.

2.3 Formal Causation and Indeterminism

Although the physical laws governing the material are not broken when life forms exert their formal causal influence on what happens, still, so the present worry goes, such influence by the organism on what is happening may break statistical laws telling us that, within the range of real possibilities left open by the physical laws, what happens is random.

That life-processes should somehow break the randomness that is dictated by the physical level is a thought that Anscombe also discussed. She illustrates her rejection of it with the following analogy:

> Suppose that we have a large glass box full of millions of extremely minute coloured particles, and the box is constantly shaken. Study of the box and particles leads to statistical laws, including laws for the random generation of small unit patches of uniform colour. Now the box is remarkable for also presenting the following phenomenon: the word "Coca-Cola" formed like a mosaic, can always be read when one looks at one of the sides. It is not always the same shape in the formation of its letters, not always the same size or in the same position, it varies in its colours; but there it always is. It is not at all clear that those statistical laws concerning the random motion of the particles and their formation of small unit patches of colour would have to be supposed violated by the operation of a cause for this phenomenon which did not derive it from the statistical laws.[36]

Anscombe's analogy is rather enigmatic, but the underlying thought is clear enough. Applying it to living beings, we get the following: we have the laws that the particles in the glass box obey – these stand for

[36] Anscombe, 'Causality and Determination', 146.

the composite matter. Then we have the fact that these particles are constantly being arranged in such a way that the word 'Coca-Cola' is formed out of patches of similarly colored such particles – that fact stands for the fact that the underlying matter happens to be doing just what is necessary for the organism to manifest and maintain itself. And just as the 'Coca-Cola'-phenomenon appears in a large variety of ways, without breaking any law of the particles, so the living organism is dynamically present without breaking any of the physical laws of its material components.

In the end, the point is this: we notice a plethora of biological phenomena around us – phenomena that, like the 'Coca-Cola'-phenomenon of Anscombe's analogy, make use of underlying material for purposes that are alien to that material taken separately – as the phenomenon of decay upon death illustrates. However, unlike the 'Coca-Cola'-phenomenon, which is completely mysterious, we can actually understand why organisms do what they do. The whole teleological order of explanation that is characteristic of living things comprises an aspect of reality – its vital or biological aspect – that is autonomous with respect to its physical aspect, yet is intimately connected to it, as it only becomes manifest on the basis of underlying physical matter.[37]

The physical components determine a range of real possibilities, which are completely independent from the wider context of the life form in which they are involved. A given amino acid molecule can, of course, bind to another amino acid – but that is just one of its many chemical possibilities. This leaves room for the life form to exploit those possibilities, thereby organizing the materials at its disposal in accordance with its nature. Recall Anscombe's chess analogy: the physical laws, determining what is really possible, are like the rules of chess. Living organisms make chess moves in accord with these rules.

[37] Compare, e.g., computers: it is highly unlikely, speaking purely physico-chemically, that our world's stuff should be arranged as it is in our computers so frequently. From a purely physical point of view, nothing further can be said about it – the coming about of these computers in no way offended the laws of nature, of course. But we *can* understand why they are there if we understand them as artifacts made by humans for specific reasons – that is, if we stop insisting on using only physical explanation and allow for other types of explanation as well.

3. Evolution and Life Forms

'Nothing in biology makes sense except in the light of evolution', as Theodosius Dobzhansky, a major figure in the development of 20th century biology, quipped.[38] The thought is that, without the idea of evolution, biology is just the inventory of the kinds of organisms that happen to be around – a huge classificatory scheme of a Linnaean kind – plus factual descriptions of the workings of ecosystems, individual organisms, and their organs and parts. With the thought that life evolves, however, this entire static scheme starts to make sense against a dynamic background: we understand, in general terms, how the life forms we find around us could have come to be instantiated, how the impressive specialization we observe could have come about, why some species are more alike than others – in short, instead of merely noting *that* the organisms around us are the way they are we come to understand *why* that is the case. It all makes sense in the light of evolution.

Now, enlightening though the thought that life evolves may be, it has also been taken to support a reductive understanding of life, and it is thought to be incompatible with essentialism about species (life forms). Life poses a threat to materialism only if these two thoughts are mistaken. And, in fact, they are – I will discuss them in turn.

3.1 Evolution and Reduction

The neo-Darwinian picture of evolution as being due to random variations feeding a 'mechanism' of natural selection is very close to the picture of a 'blind watchmaker', to use Dawkins's metaphor.[39] It invites the reductive thought I oppose: that teleology can be 'analyzed away' by using evolutionary theory as a reductive theory.

The idea of natural selection can indeed be taken as a purely physical idea, quite apart from the vital categories. A given range of

[38] Theodosius Dobzhansky, 'Nothing in Biology Makes Sense Except in the Light of Evolution', *American Biology Teacher* **35** (1973), 125–9. In that article, Dobzhansky's aim was to stress the status and importance of evolutionary theory in contemporary biology in the face of strong anti-evolutionist campaigns of religious origin. That particular controversy is irrelevant to my concerns.

[39] Richard Dawkins, *The Blind Watchmaker* (New York: Norton, 1996).

(physical) background circumstances will favor the persistence (or recurrence) of some kinds of objects and stuffs over others. As such, this idea does not distinguish between the living and the non-living (recall Thompson's 'sub-metaphysical Scylla'). To illustrate: that we find certain sorts of rocks and not others on the surface of our planet can be explained in terms of a form of 'natural selection' – the conditions on our planet were such as to favor the existing types; insofar as there were others, they turned out to be more liable to destructive influences such as erosion. Thus understood, 'natural selection' designates contingent stability of a sort that fails to capture what is distinctive of life.[40]

Of course, this does not mean that natural selection has no role to play in our understanding of animate nature. If we drop the reductionism, we can still say that natural selection determines in what way life forms appear on the scene. We are then talking about natural selection *as it operates on living organisms*. Thus understood, the idea of natural selection presupposes rather than grounds the vital categories.

It seems, then, that evolutionary theory and reductionism do not form a package deal. And I am not making a very contentious claim in drawing this conclusion. To illustrate, consider Stephen Gould's remark:

> As functionalist theories, both Lamarckian soft inheritance and Darwinian natural selection share a defining premise that environmental information about adaptive design somehow passes to organisms, and that organisms then respond by fashioning traits to enhance their competitive ability within these environments.[41]

That is to say, it is advisable to think of natural selection *as it applies to organisms*, not of natural selection *as it gives rise to organisms*.[42]

[40] Various attempts to ground the vital categories in such contingent stability can be found in the literature. They all face Thompson's 'sub-metaphysical Scylla'. I have made this point with regard to Ruth Millikan's detailed reductive account of 'proper function' and related notions, developed in her *Language, Thought, and Other Biological Categories* (Cambridge, MA: The MIT Press, 1984), in my *Conceptual Realism*, Chapter 7.

[41] Stephen J. Gould, *The Structure of Evolutionary Theory* (Cambridge, MA: Belknap Press, 2002), 1179.

[42] 'As it applies to organisms' should not be understood to include a specific stance on the debate over what the 'unit of selection' is – individual organisms, species, genes, or something else.

Evolutionary theory, thus understood, is neutral with regard to the issue of reduction.

This neutral stance seems to be widely endorsed within the philosophy of biology, as is illustrated by the first pair of chapters in the recent *Contemporary Debates* volume on that discipline, which is devoted to the question whether it is 'possible to reduce biological explanations to explanations in chemistry and physics'. Evelyn Fox Keller, writer of the first chapter, defends an affirmative answer to that question; yet she writes:

> Natural selection – at least since the neo-Darwinian synthesis and, probably, ever since Darwin – has been conventionally understood as requiring the prior existence of stable, autonomous, and self-reproducing entities.[43]

The question whether such 'stable, autonomous, and self-reproducing entities' are understandable in purely physical terms precisely is the question of reduction. Evolution does not settle that question.[44]

The need to distinguish evolutionary theory from the reductive project becomes particularly salient when considering the question how life came into being. On a materialist view, the origination of life has to be explained *without remainder* in physical terms. Yet, as we have seen, when the notion of natural selection is divorced from

[43] Evelyn Fox Keller, 'It Is Possible to Reduce Biological Explanations to Explanations in Chemistry and/or Physics', in Francisco Ayala and Robert Arp, *Contemporary Debates in Philosophy of Biology* (Malden, MA: Blackwell Publishing, 2010), 23.

[44] Interestingly, Keller and Dupré, the writers of these two chapters, which are supposed to defend opposing answers to the given question, both notice that their views do not seem to be all that distinct. Both find it important to stress that they are 'materialists' (see, resp., Keller, 'It is Possible…', 19, and Dupré, 'It is Not Possible…', 33). Keller has it relatively easy, for she can unproblematically state that '[a]s a materialist, I am committed to the position that all biological phenomena, including evolution, require nothing more than the workings of physics and chemistry' (21). Dupré, however, has a harder time stating his position. In my interpretation, he does not cleanly separate the thesis that everything is composed of matter (the non-reductive sort of 'materialism' he accepts) from materialism in the reductive sense, which precludes him from arriving at a satisfactory form of anti-reductionism. See also §2.1 above, esp. note 30.

its biological context in order to provide a reductive basis for a theory of life, the resulting notion no longer separates the living from the non-living.

On a non-reductive view, by contrast, the emergence of life may be explained by pointing at suitable physical circumstances in which primitive life forms can come to be instantiated. The entire subsequent story, however, from the first instantiation of a life form to the colorful plurality of living beings we find around us today, is then to be understood in terms of the vital categories. In such a scenario, evolutionary theory still plays the enlightening role that I mentioned at the start of this section, despite not being employed in a reductive manner. The controversy over reductionism is not about *whether* life could emerge from non-life, but rather, simply, about *what life is*, and hence what such emergence amounts to.

Still, one wonders how the first life form may have come to be instantiated at all. Anna Marmodoro provides a nicely concise statement of what this phenomenon amounts to on the broadly hylomorphic picture I have presented in §2:

> I understand Aristotle's hylomorphism as a doctrine of *instantiation by change*: the material elements facilitate the instantiation of the essential type by being transformed in accordance with the essential type's organizational principle. When the essence is instantiated, the physical components are all unified into a single thing that is structured and qualified according to the principle the essence stands for – for example, fluids come to be an embryo or a plant, or food comes to be flesh. (Marmodoro 2009: 36–7)

That is to say, the first life form became instantiated as the relevant matter changed *such as to become a living organism,* henceforth obeying the principles of that life form. Much like eggs, sugar, butter and flour may change, through an intentional action, *such as to become a cake*, which is then supposed to taste good – instantiating an artifact-form. Like natural kinds generally, life forms structure reality by formal causation wherever they are instantiated. Hence they may *come* to structure reality by *becoming* instantiated. Life forms are no different from natural kinds in this respect; they just bring their specific requirements: suitable physical conditions for them to be instantiated in.

In short, then, evolutionary theory *as such* poses no threat to the non-reductionist view on life that I am defending.

3.2 Evolution and Essentialism

Rumor has it that with Darwin's *On the Origin of Species*, biological essentialism was refuted once and for all.[45] However, as John Wilkins has made clear, rumor can't be trusted on this score:

> There is a widely held story that most people, if they have thought about the matter at all, usually hold, which has been repeated for 50 years, since the Centenary of the publication of the *Origin*. According to this view, sometimes called the "essentialism story" …[46], before Darwin species were held to be universals, classes or natural kinds, which had essential definitions. With Darwin comes recognition of the variation within species, that drives evolution by natural selection. From then on, biologists understood that species were polytypic, that they had no essential properties. Species come to be understood to be biological populations, protected against introgression by reproductive barriers ….[47]

Wilkins provides a wealth of historical materials to show that the variation supposedly uncovered by Darwin was already well-known to biologists for centuries. The essentialism that plays a role in the 'essentialism story' is a straw man. It rests on an understanding of essence that was never seriously accepted by any biologist: that a species could be defined by providing a list of necessary and jointly sufficient empirical conditions for being an instance of it.

Note the parallel with the kind of definition of life I rejected in §1: the kinds of conditions that would make up such a definition of a

[45] Charles Darwin, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (London: John Murray, 1859).

[46] The label seems to come from Georgy Levit and Kay Meister, 'The History of Essentialism vs. Ernst Mayr's "Essentialism Story": A Case Study of German Idealistic Morphology', *Theory in Biosciences* **124** (2006), 281–307. In support of his thesis on the 'essentialism story', Wilkins cites, amongst others, Gordon McOuat, 'From Cutting Nature at its Joints to Measuring It: New Kinds and New Kinds of People in Biology', *Studies in History and Philosophy of Science Part A* **32** (2001), 613–45; David Charles, *Aristotle on Meaning and Essence* (New York: Oxford University Press, 2002); and Mary Winsor, 'The Creation of the Essentialism Story: An Exercise in Metahistory', *History and Philosophy of the Life Sciences* **28** (2006), 149–74.

[47] John Wilkins, 'What is a Species? Essences and Generation', *Theory in Biosciences* **129** (2010), 141.

species either fail to mark off the relevant life form (Thompson's 'sub-metaphysical Scylla'; e.g., 'contains certain genes') or they already contain the very idea of the life form in question (Thompson's 'tautological Charybdis'; e.g., 'lions come from lions').

Thus, the 'essentialism' that is supposedly incompatible with evolutionary theory has little to do with the idea of life forms – as I noticed earlier, instantiating a life form is different even from instantiating a natural kind. Partly, the source of the confusion over what 'essentialism' amounts to lies in the historical fact that Mendelian genetics became increasingly important in the early twentieth century, after its rediscovery in 1900, leading to the development of population genetics (and ultimately to the 'modern synthesis' of genetics and evolutionary theory in the 1930s and 1940s).[48] This trend led to a quite narrow conception of essentialism:

> Essences according to the new geneticists were … genetic, and if no groups of organisms shared identical genetic constitutions, then there were no species.[49]

Since it was fairly quickly decided that species do not have such 'genetic essences', essentialism was rejected, and the very idea of biological species became suspect.[50]

Indeed, the friction between this kind of genetic essentialism and evolutionary theory is easy to see – given that evolution was thought to proceed through natural selection acting on minor changes in the genes, the resulting gradual development from one species out of another is close to incompatible with genetic essentialism. For if *all* genes together determine species identity, every minor change results in a new species (which is not a defensible position), whereas if only *some* genes determine species identity, taking the

[48] The modern synthesis, marked by a milestone publication by Julian Huxley entitled *Evolution: The Modern Synthesis* (London: Allen and Unwin, 1942), involved many of the great evolutionary biologists and geneticists of the time, including Theodosius Dobzhansky, Ronald Fisher, Sewall Wright, J.B.S. Haldane, Bernhard Rensch, and Ernst Mayr. See Gould, *The Structure of Evolutionary Theory*, Part I, esp. ch. 7.

[49] Wilkins, 'What is a Species?', 144.

[50] For the relevant background, see John Wilkins, *Species: A History of the Idea* (Berkeley: University of California Press, 2009), chs. 5–7. And for a recent defense of something like genetic essentialism see Michael Devitt, 'Resurrecting Biological Essentialism', *Philosophy of Science* **75** (2008), 344–82.

'genetic intersection' of all members of a given species will result in far too inclusive species demarcations.[51]

Despite all these philosophical troubles, both pre- and post-Darwinian biologists 'in the field' appear to have been struggling (and are still struggling) with the very same, serious question: what it takes for a given individual organism to belong to one or another species. Put in Aristotelian terms, they are interested in 'what-it-is-to-be' a member of that species – which is (roughly) Aristotle's original term of art that came to be translated as 'essence'. The overall take on the issue appears not to have radically changed since Darwin; it is just that evolutionary and hereditary perspectives have been added to the mix – and have dominated it, of course.[52]

[51] One way of escaping this conclusion is by endorsing 'saltational evolution'. Darwin, who supported the thesis *natura non facit saltus* (see *On the Origin of Species*, 194), was a 'gradualist', thinking that evolution proceeds by accumulation of many small steps (see Gould, *The Structure of Evolutionary Theory*, 146–55). But there were (and are) those who believed that some kind of jump-like macro-evolution was necessary to account for the larger differences observed in nature. See, e.g., William Bateson, *Materials for the Study of Variation* (London: MacMillan & Co. 1894), and in particular Richard Goldschmidt, *The Material Basis of Evolution* (New Haven CT: Yale University Press, 1940), who famously named the envisaged results of such larger jumps of nature 'hopeful monsters' (see Gould, *The Structure of Evolutionary Theory*, 390–3). Though ridiculed by the neo-Darwinians, who were establishing the 'modern synthesis' in those years, Goldschmidts ideas have been partly vindicated by later scientists; cases of saltational evolution and even his 'hopeful monsters' have been identified and studied. See, e.g., Günther Theissen, 'The Proper Place of Hopeful Monsters in Evolutionary Biology', *Theory in Biosciences* **124** (2005), 349–69 and Robert Page *et al*., 'Microarray Analysis of a Salamander Hopeful Monster Reveals Transcriptional Signatures of Paedomorphic Brain Development', *BMC Evolutionary Biology* **10** (2010), 199.

[52] E.g., Ernst Mayr proposed – and refined over the years – his 'biological species concept'. An early formulation: 'Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups' ('Speciation Phenomena in Birds', *American Naturalist* **74** (1940), 120). A later formulation: 'A species is a protected gene pool. It is a Mendelian population that has its own devices (called isolating mechanisms) to protect it from harmful gene flow from other gene pools' (*Populations, Species, and Evolution* (Cambridge, MA: Belknap Press, 1970), 13). As Wilkins notes, however, it seems that Mayr is more concerned with the epistemic than with the ontological aspects of being a species (Wilkins, *Species: A History of the Idea*, 189).

According to Wilkins, looking through the layers of philosophical troubles reveals the core of that mix to be as follows:

> If species are indeed thought to have essences, they are of the developmental kind – a lifecycle that reliably generates the morphology, ecological niche occupancy and behavior that is typical.[53]

This is, more or less, what Wilkins calls the 'generative species concept'. Wilkins takes species, as they have been studied throughout the history of biology from Aristotle onwards, to have been understood not as 'logical species' characterized by clear-cut definitions, such as the genetic one, but rather as 'natural species', along the lines of his generative species concept. Claims about such natural species do not hold strictly invariably but rather 'for the most part' (as Aristotle would say).[54] Though perhaps not identical to my notion of life forms, Wilkins's generative species concept does come close – a lot closer than the 'essentialism' that was allegedly refuted by Darwin.

It is no overstatement, then, to say that the Darwinian and genetic revolutions have not freed us from an inadequate form of essentialism, but have rather turned our understanding of what life forms are, which was already a difficult matter, frankly into a conceptual mess. The ongoing discussion amongst biologists and philosophers of biology over the problem of what demarcates a species – morphological or physiological or genetic characteristics, possibility of interbreeding, evolutionary history, etc. – in fact illustrates this claim. Wilkins compiles a list of 26 different species concepts in use by biologists today, writing:

> Here is a working list of species concepts presently in play. … [F]or philosophical reasons, I think there is only *one* concept – "species", and all the rest are *conceptions*, or definitions, of that concept.[55]

I identify the one concept with *life form*, a basic vital category; the many conceptions arise from a (perhaps too narrow or exclusive) focus either on certain families of life forms (e.g., higher animals)

[53] Wilkins, 'What is a Species?', 144.

[54] See Wilkins, 'What is a Species?', 142. He also refers to Wittgenstein's notion of 'family resemblance' (145), remarking that family members resemble each other, of course, because of shared generative histories.

[55] John Wilkins, 'A List of 26 Species "Concepts"', *Science Blogs: Evolving Thoughts*, retrieved December 16, 2015: http://scienceblogs.com/evolvingthoughts/2006/10/01/a-list-of-26-species-concepts/

or on certain typical distinguishing features of life forms (e.g., morphological or genetic features). It is an interesting challenge, for the science of biology in general, to tie them all together – it illustrates how diverse life forms can be.

From the non-reductive perspective I advocate, we can make three general remarks that may help clear up the conceptual mess. First of all, one should not expect the kinds of definitions familiar from mathematics or even physics or chemistry ('logical species') to be available when it comes to life forms. Life forms are intricate, teleologically unified principles governing the full life cycle of their instances, including interrelations with other life forms.

Secondly, and relatedly, that universality fails in the way it does – that there seem to be no features that are shared by all and only members of a given species – is actually typical of the vital categories: organisms can fail to display features they *should* display, and can fail to engage in life-processes they *should* engage in. That is not a problem for species essentialism, it is an interesting feature of it – it illustrates the teleology inherent in the vital categories.

And, thirdly, since, like in the case of physical kinds, it takes empirical investigation to identify the life forms that organize biological reality, from an epistemological point of view it is not so surprising that the *conceptions* individual biologists have of species in general – and, for that matter, of any given species in particular – is often a mixture of *epistemically* relevant indicators and more fundamental aspects. Moreover, life forms are in this respect more difficult, epistemically speaking, than physical natural kinds. It seems that we have to get to know life forms via their characteristic phenomena, via their specific way of organizing the underlying stuff, their specific way of living. The phenomena in which life forms are expressed may thus encompass all the different aspects that figure in the biologists' diverse species conceptions: ranging from relevant processes on the molecular level to genetic, morphological, physiological and behavioral phenomena, and from their roles within encompassing ecosystem(s) to their roots in evolutionary history.

Genetics and evolution have greatly enhanced our understanding of the living. And, given the prevalence of materialist thinking, it is not surprising that both ideas have been put to use for a reductive understanding of life. Having rejected this materialist reductionism, we may think of genetics and evolution as themselves vital phenomena, means by which life forms come to instantiate themselves in the ways they do. That is, there is no *need* anymore to insist that mutations are 'blind', not governed by the life form in which they occur. Mutations may well happen for a

reason.[56] On the other hand, there is no need to deny 'blind' mutations either. What is most important is that the reasons for thinking one way or the other is not a presupposed reductionism, based on materialism, but rather a sober look at what is actually 'out there'.

This concludes my elaborate attempt to make sense of the autonomy of the vital categories given the prevailing strong bias towards materialist thinking. Taking the vital categories metaphysically seriously, which we should do if we continue to make use of them, implies endorsing a non-reductive view like the one I have sketched. It is an exercise in unification without reduction, in holding together the unity of reality with the variety of phenomena it contains. The result is a pluralist understanding of reality, where the diversity of things inhabiting reality – physical objects, living organisms, and presumably other sorts of entities – is mirrored in the diversity of forms of understanding we employ to comprehend them. Materialism closes its eyes for the evident differences between the living and the non-living. Life poses a challenge to materialism, because materialism lacks the resources to understand it.[57]

[56] In fact, empirical support for this way of thinking can be found in the varieties of epigenetic inheritance – inheritance of acquired traits – that are currently being researched. Eva Jablonka, Marion Lamb, and Gal Raz present interesting findings, and argue that '[i]ncorporating epigenetic inheritance into evolutionary theory extends the scope of evolutionary thinking and leads to notions of heredity and evolution that incorporate development' (Jablonka and Raz, 'Transgenerational Epigenetic Inheritance: Prevalence, Mechanisms, and Implications for the Study of Heredity and Evolution' *Quarterly Review of Biology* **84** (2009), 167). They view themselves as 'challenging the modern synthesis', with its narrow focus on genes as the sole locus of evolution, and reintroduce ideas from the history of evolutionary theory that were banned from the modern synthesis because they do not fit the reductive project – e.g., Lamarckian ideas and saltational evolution (see note 50 above). See Jablonka and Lamb, *Evolution in Four Dimensions* (Cambridge, MA: The MIT Press 2005); Jablonka and Lamb, 'Bridging the Gap: The Developmental Aspects of Evolution', *Behavioral and Brain Sciences* **30** (2007), 378–89; and Jablonka and Lamb, 'Soft Inheritance: Challenging the Modern Synthesis', *Genetics and Molecular Biology* **31** (2008), 398–95.

[57] For this essay, I have benefited greatly from conversations on its central ideas with the following people: Niels van Miltenburg, Thomas Müller, Dawa Ometto, Michael Thompson, Antje Rumberg, and Joeri Witteveen. I also gratefully acknowledge financial support from the European Research Council, under the European Community's Seventh Framework Programme (FP7/2007–2013), ERC Grant agreement numbers 263227 and 616512.

Jesse M. Mulder

JESSE M. MULDER (j.m.mulder@uu.nl) *is Assistant Professor of Philosophy at the Department of Philosophy and Religious Studies of Utrecht University, The Netherlands. Recent publications include* Conceptual Realism: The Structure of Metaphysical Thought *(Utrecht University: PhD Thesis, 2014), and 'The Essentialist Inference'* in Australasian Journal of Philosophy.

https://doi.org/10.1017/S0031819116000024 Published online by Cambridge University Press