

# THE PLACE OF PHILOSOPHY OF PHYSICS IN PHYSICS AND PHILOSOPHY: A RESPONSE TO MICHAEL DUMMETT

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## ABSTRACT

The paper is an attempt to react as direct and as close as possible on Dummett's 2007 paper by addressing his overall theses about bridging the gulfs between philosophers and physicists and between analytical and continental philosophy on the one hand and, on the other hand, picking up a couple of more detailed issues Dummett raises about physics and its philosophy.

**Keywords:** philosophy, high culture, philosophy of physics, indiscernability, underdetermination, materialism

Sir Michael Dummett has presented an invigorating diagnosis of what he considers to be the place of philosophy in European culture.<sup>1</sup> His diagnosis is lucid and profound, which makes the task of commenting on it a notably hard one. And this is even more so true for someone who basically shares all of his main theses. In particular, I do very much agree with his main concern about the paucity of dialogue between philosophers and physicists. Dummett's diagnosis leads to the conclusion that philosophy must bridge two gulfs: while the first gulf lies between philosophers and scientists (especially physicists), the other lies within philosophy itself pertaining to the widely perceived distinction between analytical and continental philosophy. And although the guest editors of this special issue have asked us to concentrate on the first gulf, I feel tempted to react to some other remarks of Dummett's as well. I will thus proceed by citing passages of Dummett's paper<sup>2</sup> which I found particularly interesting and which give me the opportunity to direct reactions, roughly in the order in which

<sup>1</sup> The reader may be referred not only to paper (Dummett 2007) but also to his 2010 book.

<sup>2</sup> Unfortunately, the printed version of Dummett's paper contains a lot of typos and grammar mistakes. I will use double square brackets [...] to indicate my own corrections or hints on misprints within the quotes.

they appear in his text.

Dummett's discussion starts with an identification of the criteria of culture. For something to be a component of high culture it must "demand great skill of its creators" and it must "elevate the mind or the sou"<sup>1</sup>. But this is not sufficient. Dummett takes the example of mathematics to show that there's a third criterion to be met: for something to be a component of high culture it must also be a component of the life of many people. Mathematics fails in this respect – as well as the natural sciences and, I take it, any formalized science in general (including logic and computer science).

The further mathematics and the natural sciences have advanced, the less and less have they been reckoned as what every cultivated person may be expected to know about. The natural sciences remain very influential, however, not directly through people's knowing about them, but by apparently authoritative pronouncements by scientists about their implications. (Dummett 2007, 23; 2012, 17)

Here I'm not so sure. It is sadly true that a cultivated and even an intellectual person in our Western world is not expected to know much about science. But is the nevertheless existing influence of the sciences really elicited and determined by "authoritative pronouncements by scientists"?

Let me tell a mundane story. Just recently I witnessed a piece of a radio show where people phone and chat with the DJ on air. Asked about her profession, one listener told that she worked as a mathematics teacher in high school. This was met with incomprehension on the radio host's part. He couldn't understand that someone (a woman in particular) chose mathematics as her subject. The listener tried with the brave reply that mathematics is the language of nature and that studying the language of nature is a fascinating enterprise. That culminated in an even greater ignorance on the part of the radio host who literally didn't understand the listener's claim. Obviously, the idea of studying the language of nature was beyond the DJ's scope. Perhaps it was the element of abstraction necessary to grasp the link between mathematics and the natural sciences. But I doubt that the reaction would have been a lot different, had the listener been a physicist rather than a mathematician. The point is that the layman doesn't seem to reflect at all about where the achievements of technology stem from. And this is true despite the fact that we are apparently living in a high-tech world. It is even true for someone sitting right in the middle of a broadcast studio talking to other people outside on their mobile phones while all of this is simultaneously broadcasted to hundreds of thousands of people afar.<sup>3</sup>

The influence of science, I'm afraid, has one simple and bovine reason: its technological applications. But because of the high level of specialization and sophistication of science and, accordingly, of the transformation of science into technology they both,

<sup>3</sup> I admit that the relationship between science and technology is in fact more complicated and not as linear as suggested in my banal example. But whatever the relationship is, mathematics is of course important for both science and technology.

science and technology, became extremely remote to the general public. Most people simply take the achievements of science as given, just as our predecessors took nature and natural forces as God-given. However, the remoteness of science from everyday life has serious implications. For the more remote modern science and its transformation into high-technology are, the less “authoritative” are the scientists’ statements – at least in the eyes of the general public. In the eyes of many, scientists do weird things which have nothing to do with everyday life and practice. There is technology, yes, but who knows and who cares where it comes from? And who cares about valuing how amazing it is? The logic of the miracle argument for realism in science, the otherwise unexplainable fact of the tremendous success of science, becomes totally unnoticed by the vast majority of people. I’m not arguing here in favour of scientific realism (though I’m certainly in favour of it), what I want to point out is that the miracle argument has a *prima facie* plausibility usually felt and respected by anybody who is scientifically informed (realists and anti-realists alike). The fact that this superficial plausibility is beyond the scope of most of the people is a serious indicator of the dangerous remoteness of science. Science is no longer and not always judged as important. Scientists aren’t no longer and always judged as important, and – their statements aren’t always considered to be highly authoritative. What we can actually observe in high-tech societies is that quite the contrary happens. We see a dangerous return of pseudoscience, religious fundamentalism and even mysticism.

But perhaps my Philippic is beside the point, because I’m not talking about ‘high’ culture here. I do not speak about the general ‘educated public’, as Dummett does. But is there really such a clear divide? My worry is that what I just pointed out carries over to many of the so-called educated or even highly educated. It carries over to many working in the humanities, in art and also in the social and political sciences. So my worry is in fact even greater than Dummett’s. While he worries about the lack of information among philosophers about science only, my worry is that the general remoteness of science has already brought forth serious and worrisome impacts.

Has the same happened to philosophy?

No. [...] although philosophy gave birth to physics and, more recently, to other sciences, it is not seen as a ‘technical’ subject, like mathematics and natural sciences, or even the social sciences such as economics. It is available to the general educated public as the technical subjects are not, save to those who have been trained in them. [...] Philosophy has not therefore lost its place as part of high culture, as have the natural sciences and mathematics. (Dummett 2007, 23-24; 2012, 17)

That sounds too good to be true. Whom does Dummett have in mind here? And what level of sophistication must we presuppose to come to the judgement that philosophy has not lost its place as part of high culture? Certainly, it is not sufficient to hear quotes from great philosophers like Plato, Aristotle or Kant in the soap-box oratories of politicians or representatives of the cultural scene. (Something comparable has happened to science, too, and even stronger: figures like Einstein, Darwin and

Hawking became part of modern pop culture.) I agree that philosophy is not seen as a ‘technical’ subject, but this I would rather consider as a problem. Isn’t the actual technical level of philosophical discourse in fact comparable to the technical sophistication of physics and mathematics – at least to a certain extent? Nobody in the general educated public has any idea about topics like mental externalism, mereology, possible worlds, teleofunctionalism, supervenience, zombies, tropes, or 2D semantics. And what is more, there are lots of highly technical terms which falsely sound innocuous to the general public like ‘meaning’, ‘property’, ‘proposition’, ‘natural kind’, ‘causation’, and many more, since they are used in ordinary language without further reflection. But how different do they sound to a philosopher’s ear? As specialists, all of us know very well about the deep philosophical problems and obstacles connected with each one of them. So my worry goes quite into another direction than Dummett’s: many people *believe* that they know something about philosophy (or that they could easily delve into it if necessary), but do in fact heavily underestimate the level of technical sophistication of good philosophy.

I was impressed when an Italian daily newspaper ... printed articles on philosophy... Though I am ashamed to say that this would be unimaginable in Britain, I believe that something similar would have been possible in a French or German newspaper, and perhaps in other European countries. (Dummett 2007, 24; 2012, 18)

As a German I am perhaps allowed to object. And this connects with the point before. Let me illustrate this with a concrete example. During recent years there was quite an extensive discussion going on in some decent German newspapers and journals about the problem of free will. So this seems to speak in favour of Dummett’s point. But the discussion was mostly quite unsatisfactory and disappointing. It was generally presented as a fight between neuroscience and philosophy. And I cannot help feeling that, by and large, the philosophers succumbed. There are three points to consider here. Why, for instance, must one generally think of philosophers as being a fighting opponent to what the scientist says? The journalists seemed to expect this. First point. Since this was a debate between philosophers and neuroscientists one would have naturally expected (at least I would!) to hear more philosophers of science talking about the general issues providing the background of the debate as for instance (mental) causation, levels of complexity, reduction, and laws of nature. But I don’t remember, and this is my second point, even one philosopher of science involved in those interviews. The third point is that the problem of free will is quite tricky (as of course the majority of ‘real’ philosophical problems). Whatever position one prefers in this muddled debate, it requires careful and subtle conceptual analysis – and there is simply no space for this kind of reasoning even in high quality newspapers (I got the impression that many colleagues already failed to make the simple and basic distinction between ‘reasons’ and ‘causes’ understandable to their scientific dialogue partners, let alone to the general educated public).

Philosophy cannot assume the triumphant posture that the natural sciences take up. It has made great progress since it was initiated by

the ancient Greeks; yet there are few philosophical problems that have definitively [[been]] solved. [...] outside logic, there are few theories which all philosophers accept. (Dummett 2007, 25; 2012, 19)

I like this statement very much and I'm ready to believe it. Though I still wonder what the few theories are that all philosophers accept. Here's an example of recent progress in philosophy of physics with a strong impact on philosophy in general: Ontology demands a clear understanding of the concepts of identity and individuality. The classic is Leibniz' principle of the identity of indiscernibles (PII). With the advent of quantum theory (since the late 1920's) this principle was considered to be violated by nature. Quantum objects, bosonic particles in particular, obey a statistics of indistinguishable particles, meaning that in order to be in accordance with empirical results arrangements of particles in many-particle-states can only be counted as physically distinguishable up to permutations of single particles. French and Redhead (2008) have argued, however, that a metaphysical notion of individuality in terms of haecceity (transcendental individuality, primitive thisness) can nevertheless be retained in quantum theory. More recently, Saunders (2006), following earlier work of Quine, has shown that although fermions are not absolutely Leibniz-discernible (in terms of intrinsic properties), they are nevertheless weakly discernible by means of irreflexive relations (a relation  $R$  is irreflexive if for all  $x$  in the domain  $\neg R(x,x)$  holds). Muller and Seevinck (2009) have then extended this result to quantum objects in general by considering relations based on complementary observables. This shows that at least a weak notion of individuality and, hence, a weak Leibniz principle are compatible with quantum theory. This is a remarkable example of the possibility of progress in philosophy. It is a progress in our metaphysical understanding of physics: there is now the option to stick with a notion of individuality, albeit a weak notion, but stronger than a mere haecceistic concept of individuality.

What is a genuine cause of regret is the paucity of dialogue between philosophers and physicists. The generality of philosophers know too little physics to dare to venture to treat of the philosophical problems it raises, or to take due account of physical theories when addressing problems on which they bear... [[sentence misprinted]] Here I disagree with the bold claim of the manifesto that analytic philosophers are both humanists and scientists: they may respect physics, but they do not know it. Specialist philosophers of physics speak a technical language among themselves, and fail to communicate with other philosophers in the mainstream.

Physicists are aware that their subject raises many conceptual difficulties, but do not imagine that either a training in philosophy or a discussion of these difficulties with philosophers would help in solving them. (Dummett 2007, 25; 2012, 19)

As I already indicated at the beginning, I decidedly agree with Dummett's general analysis: there is a said paucity of dialogue between philosophers and physicists – and the two major reasons for this are the ones he mentions. On the philosophical side even analytic philosophers pay mostly only lip service to the sciences, on the scientific side

the idea that philosophy could help scientists to make progress with their own problems is almost non-existent. Those two points must be considered carefully one after the other. Let us first have a look at the relationship between physics and philosophy.

Never before, I believe, have philosophy and the natural sciences been so far apart. (Dummett 2007, 26; 2012, 20)

Admittedly, the dialogue between philosophers and physicists is meagre, but it might have been even worse in former times. As I see it, the main origins of the divisiveness between science and philosophy lies in the raising of the German romantic-idealistic Naturphilosophie (natural philosophy) in the 19th century. This is not to say that Schelling, Fichte or Hegel did not know about the science of their time, but their firm conviction was that the empirical method of the more and more developing and establishing Naturwissenschaft (natural science) alone does not suffice to tackle questions about nature's nature. It had to be supplemented with elements of speculative, transcendental or in some other form "genuinely philosophical" knowledge. But empirical Naturwissenschaft had already started its triumph in terms of technological and industrial success and innovations, leaving speculative Naturphilosophie behind. So perhaps already in the the 19th century things had been worse. But be that as it may, history is of little help for our present situation.

What is also of little help are some of the incidental hostile statements from prominent physicists against philosophy, even philosophy of science. As Feynman once put it: "Philosophy of science is about as useful to scientists as ornithology is to birds." Steven Weinberg or Stephen Hawking provide further examples. But on the other hand we have Einstein, Bohr and Heisenberg, or, to mention active scientists, Carlo Rovelli and Gerard 't Hooft, who are friendly and greatly open to discussions with philosophers. As usual, bad exceptions don't prove the rule. Indifference, not hostility, is the main problem.

But how to overcome indifference? Dummett seems to recommend that issues of metaphysics can help to bridge the gulf.

The nature of reality is of course the subject-matter of that branch of philosophy which we call metaphysics: the philosophy of physics is a substantial part of metaphysics. Different interpretations of one and the same physical theory – quantum mechanics, for example – yield what are in fact different but, for the time being, empirically equivalent physical theories. We have, however, no examples of empirically equivalent theories – or that yield the same predictions of observable events – that is demonstrably not logically equivalent – capable of translating into one another and I doubt if there are any [[sentence misprinted]]. So the interpretation of physical theories is not a matter only for those with philosophical concerns, irrelevant to practising scientists. It can never be held for certain [that] the empirical results

will not favour one interpretation as against another. (Dummett 2007, 26; 2012. 19-20)

Dummett seems to recommend that metaphysics and the realism debate, obviously scientific realism in particular, are especially important topics to help (re-)establishing the link between physics and philosophy. As an example, he hits upon the issue of theory underdetermination. I emphatically applaud to this, because I fully share his doubts about the existence of intriguing cases of underdetermination. And by ‘intriguing’ I mean cases which are pressing cases at the front line of actual research and which are considered as cases of insoluble rivalry by the scientists themselves. The failure of the philosophy of science literature to pinpoint such cases is, I believe, a failure of the underdetermination thesis itself (Lyre 2011). The only half-convincing case of an underdetermination scenario in actual science is, as Dummett again rightly points out, the case of quantum theory with its never-ending interpretational debate (I will mention another case below, though). My personal guess is that this peculiarity of quantum theory together with a second peculiarity, the quantum measurement problem (two peculiarities which together make quantum theory really unique in the scientific landscape), is a strong indicator for the preliminary character of quantum theory as a fundamental theory (Lyre 2010).

But the interest of physicists in foundations of quantum theory is nevertheless meagre. The main reason is that the vast majority of physicists simply makes no contact with foundational questions in their everyday work. Physics, as any other science, has become a science of the complex. And most of the interest in the plethora of complex and higher-order problems has to do with the prospects of direct applications of scientific endeavours. Hence, the reasons for why science might be interested in philosophy must be distinguished along the lines of application versus foundations just as science divides into applied and foundational. This means that, for one, there is interest in philosophy insofar as it might help to overcome specialized problems in complex and higher-order regimes, and for another, there is interest in the prospect of providing foundations. But the foundational part of science nowadays certainly takes less than 1 percent of science *in toto*, and this also drastically shapes the role of philosophy in science. For quite some years now we can already observe a development towards philosophical interests in particular scientific disciplines (one might only compare the section titles of the major philosophy of science conferences world-wide in the last 10 or 15 years and how they shift away from classical foundational questions to more concrete and specialized problems).

Curiously, the decreasing interest in foundations can even be seen in foundational science itself. I’d like to illustrate this by another concrete example. Since a couple of years I am involved in a research project on the ‘Epistemology of the LHC’ run by physicists as well as philosophers and historians of science. My experience is that the physicists are indeed interested in the cooperation with philosophers and historians of science, insofar as they see a real chance to get insights and hints for possible progress with their everyday work. In the particular case of our project, however, the reason lies mainly in the extraordinary dimension of the LHC – as a physical experiment and

in terms of its methodology and logistics. In order to sustain such an experiment the scientists involved feel the need to understand the methodology and the functioning of their own science better and more deeply. The bigger part of our project therefore focuses on the nature of modelling and the relationship between theory and experiment under the conditions of big science. A smaller project also focuses on ontology (particularly on the ontology of the so-called Higgs mechanism and, more generally, on spontaneous symmetry breaking in quantum field theories).

I can report the same experiences from another field, the philosophy of mind and cognition. Here again the practicing scientists sometimes like to chat about the big questions of the mind or consciousness, but this mainly holds for occasional after-work discussions. Their real interest in philosophers, if there is any, is to incorporate them into designing concrete experiments and to help interpreting the results (mostly by clarifying the used concepts). And this of course presupposes the willingness of the philosopher to delve into the particular technicalities involved.

Thus, by and large the interest of science in philosophy has already shifted from interest in foundations to special, usually far more complex problems. And it must be expected that this shift will proceed further. In this respect foundational and metaphysical questions will play only a subordinate role for the future link between science and philosophy. The pressure of applications in science also finds its expression in the link between science and philosophy. And this of course also has to do with time scales since the impact of a project on foundations is always less visible and measurable than on more specialized problems. To put it the other way around: whether training in philosophy and discussions with philosophers help the physicists to solve their foundational mathematical problems is not so clear, nor should it be the benchmark of the cooperation. In the case of foundational science the impact of interdisciplinarity is rather indirect and certainly not immediately seen.

This is, *per se*, not a tragic result. After all, philosophy of physics and physics aren't and shouldn't be the same. So there are questions which are of interest for the philosophers of physics only, and vice versa. Moreover, as far as teaching is concerned, things are slightly different. My own experience with colleagues from physics and physics students alike is that they are quite interested and sometimes even enthusiastic about philosophy of physics classes, although the direct impact of the (mainly foundational!) topics in such events for their daily work cannot immediately be seen.

Having talked about the relation between physics and philosophy we must now concern ourselves with the relationship between philosophy of science, or more particularly, philosophy of physics and philosophy in general.

I should not like my remarks about physics to be heard as a retraction of my earlier disparagement of scientific attitudes on the part of some philosophers, who take materialism as axiomatic although it is doubtful whether they could clearly explain what matter is. Because of the manifest great successes of the natural sciences, many scientists

have adopted an arrogant attitude to the effect that all we know we know by science. (Dummett 2007, 26; 2012, 20)

It's always hard to make general claims about the scientists' attitude. It seems to me that there are almost as many realists as there are anti-realists, as many reductionists as there are anti-reductionists, but still the majority, I think, simply adopts an instrumentalist or rather a pragmatist attitude towards science (meaning, again, that they don't care about philosophy at all).

In talking about the scientific attitudes on the part of some philosophers, however, Dummett hits upon a subtle point. I also find it a disturbing fact that the label 'materialism' has such a widespread use in philosophy, mostly in philosophy of mind. In fact, nobody is able to explain what matter is. Matter is one of the great mysteries of modern science. I already mentioned the Higgs mechanism. This mechanism is supposed to give an answer to the question of how elementary particles acquire mass (and it hinges on the still yet to be discovered Higgs boson). But there are strong reasons to doubt that this 'mechanism' is a mechanism in any causal or dynamical sense of the word (cf. Smeenk 2006, Lyre 2008). While it is rather tricky for the masses of the weak gauge bosons, the Higgs mechanism can quite easily be understood in its application to the fundamental fermion fields  $\Psi$ . Start from a Yukawa coupling  $L \sim g\bar{\Psi}\Phi\Psi$  to a scalar field  $\Phi$ . By rewriting  $\Phi$  as a superposition of  $v$  and  $H$  we get  $L' \sim g\nu\bar{\Psi}\Psi + g\bar{\Psi}H\Psi$  now consisting of a fermion mass term with  $m=g\nu$  and a not yet detected coupling between  $\Psi$  and the Higgs boson  $H$ . Quite obviously, the simple rewriting  $L \rightarrow L'$  of the Yukawa term should not be confused with a causal process in nature. Moreover, all of the fermion mass parameters (different values of  $g$ ) must be put in by hand, so this 'mechanism' provides us with no explanation of the particular fermion mass spectrum and values.

Moreover, even a possible derivation of a mass spectrum must still be distinguished from an explanation of the very nature of mass and matter. Special relativity considers rest mass as a form of energy. Very roughly put, in the Higgs mechanism the vacuum energy of a given field  $\Phi$  is 'rearranged' so as to appear as the masses of the Standard Model particles. But this provides us with no deeper explanation of the nature of energy-matter itself. The concept of energy-matter is still a primitive concept of modern physics. Metaphysically speaking, it is as opaque as the concept of mind.

But while physics may have difficulties in explaining the ultimate nature of matter, this does not imply the impossibility of either physicalism or reductionism. It simply implies that the physicalist assumption that 'the physical' is basic (whereas, for instance, 'the mental' is not) does not follow from any principal grounds but must be established by empirical science itself. On the basis of physicalism we can explain and understand by far more empirical findings and possible interconnections between the various levels in science (from the physical to the neurobiological to the cognitive and the mental...) than by any other assumption about the nature of the bottom level. This is in accord with the above observation that certain physicalist key terms such as matter and mass are still primitive and, in a sense, opaque terms.

The request of an empirical understanding of the interconnections between the various scientific levels shows the natural affinity of physicalism to reductionism. In the past, philosophers have drawn heavily on the concept of supervenience to spell out both the doctrines of physicalism and reductionism. The curious fact, however, that (a particular variant of) supervenience already fails within physics itself was seldom considered or taken seriously outside the philosophy of physics community. Supervenience fails for two reasons within physics. The first is well-known and is due to the phenomenon of entanglement in quantum theory: there are properties of a compound quantum system that do not supervene on any assignment of the properties of their parts. Such failures of supervenience may likewise also be characterized as non-separability or holism (Howard 1985, Healey 1991). The second is less known and is due to holonomy effects in gauge theories (with the Aharonov-Bohm effect as the most shining example). Think of holonomies as non-local entities defined on closed loops in spacetime. In the Aharonov-Bohm effect the electromagnetic properties of loops do not supervene on any assignment of the properties at the spacetime points that constitute the loops. This must be understood as a general feature of gauge theories. Given that all of the four fundamental interaction theories in modern physics are gauge theories, this is a quite general and important result (Lyre 2004, Healey 2007).

Nevertheless, this result does not speak against supervenience *per se* but mostly against a localistic or pointillistic supervenience base – as for instance adopted by David Lewis in his infamous doctrine of Humean supervenience. Nature seems to tell us that non-local entities should rather be considered in the base. Holonomies are a case at hand. From a general metaphysical perspective, my view is that structures as fundamental entities should constitute the fundamental supervenience base. Let me explain this by pushing the present example a bit further. As I've argued elsewhere (Lyre 2004), the Aharonov-Bohm effect and comparable non-local effects in gauge field theories leave us with a case of underdetermination on the level of 'object-like' entities – be they either field strengths, gauge potentials or holonomies – by mutually violating or being conform to one or two of the three different basic locality assumptions in physics: local action, point-like interaction and separability as well as observability as a fourth criterion. In other words: experiment leaves our ontology underdetermined. Whether and which locality assumption one wants to adopt is in part a metaphysical decision in the sense that some such assumptions must already be presupposed in order to do physics as an empirical science. So on the one hand we get an old result: you can't simply read off your metaphysics from physics.

On the other hand, however, we may very well ask whether this is a pressing and intriguing case of underdetermination in the above sense: "a case of insoluble rivalry as considered by the scientists themselves"? Actually I don't think so. Due to coherence and other comparable criteria with respect to other branches of theoretical physics, most physicists would, I take it, be in favour of the holonomies option. But one might also go a step further and argue that what remains invariant in all three scenarios (field strengths, potentials, holonomies) is the gauge group structure of the underlying gauge field theory. With such a move we restrict our realist focus on structure rather than on any particular object-oriented ontology. This view that I'm favouring here,

the view of structural realism, is a moderate version of scientific realism that in many respects indeed provides a tailor-made metaphysics for modern physics (cf. Bokulich and Bokulich 2011).

It may be argued what I have said about physics applies equally to other sciences, neurophysiology for instance, which concern human nature more than the nature of physical reality. That may be so: the problem is certainly not specific to physics, though I personally think that the philosophical conundrums raised by physics are deeper as well as more difficult than those raised by other sciences. (Dummett 2007, 26; 2012, 20)

Perhaps Dummett is right. But this does certainly not relieve philosophers of science from delving into the special sciences, especially the cognitive neurosciences. Philosophy of science has far too long focussed on physics as the paradigm example of science. This is a serious fault, as our discussion has already shown. It must perhaps be considered *the* task of philosophy of science at the beginning of the 21<sup>st</sup> century to delve into the more specialized higher-order sciences. Issues of confirmation and explanation, of what scientific models and theories are, of experimental methods and theory ladenness, of laws of nature, of intertheory relations and reductionism, and, finally, of scientific realism change considerably when imported into the special sciences.

But there's also another important aspect to be mentioned here. We have spoken about the neglect of physics and philosophy of physics by philosophy in general. But almost the same is true for the special sciences. The lack of knowledge about physics among biologists, cognitive scientists, economists, or social scientists, to mention just a few, is sometimes about as big as among philosophers. Philosophers of science, insofar as they are informed about physics, might be of considerable help here. This is particularly related to the issue of reductionism. Judgments about reduction and intertheory relations are at the same time judgments about the importance of lower-level science in constraining higher-level science. In my view, this opens a highly interesting prospective working area for philosophers of science with a direct impact and relevance for science in practice.

Two tasks lie before us, two gulfs are for us to bridge. One is that between philosophers, of all schools, and scientists (particularly physicists); the other that between divergent philosophical schools – between analytical philosophy and that amorphous style perhaps by contrast with analytical philosophy it should be called 'synthetic' philosophy misleadingly labelled 'continental' [[sentence misprinted]]. (Dummett 2007, 29; 2012, 22)

Dummett's paper centers around the place of philosophy in European culture. His final thesis is that the second gulf, the one between analytic and continental philosophy, might best be bridged in Europe. I would like to add that in order to bridge this gulf one must simultaneously clarify the relationship between philosophy and science.

Hence, the two gulfs hinge together. I earlier claimed that one of the chief reasons of the divisiveness between science and philosophy had been the rather speculative nature of 19th century continental philosophy. But an all-too naïve, uncritical picture of science, which is not grounded in a deeper understanding of science, as can be found in many areas of analytic philosophy, is not of great help either. So both wings have to clarify their picture of science. And this implies a certain readiness to engage into scientific technicalities.

But a third gulf is yet to come. It is the gulf between applied and foundational science that carries over to philosophy of science and, accordingly, to any scientifically informed science. Here I can only speculate about what the future might bring. One vision is that, eventually, the gulf between applied science and foundational science might become larger than the gulf between foundational science and philosophy (instances of which can already be seen). And when the time comes, philosophy might perhaps help to overcome that third gulf. But this will be another story.

**Acknowledgements:** Many thanks to Ramiro Glauer, an anonymous referee, and the editors, Angelo Cei and Mauro Dorato, for helpful remarks and suggestions.

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Received: September 5, 2011

Accepted: May 28, 2012

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