Is Physics Complete?
An Argument Against the Completeness of Physics

"In science, there is only physics. All the rest is stamp collecting." –Ernst Rutherford

"I suppose one can imagine a world where all the big things are made out of small things, and there are laws about the small things and there are laws about the big things, but some laws of the second kind don't derive from any laws of the first kind." –Jerry Fodor[1]

1. Introduction

Among contemporary philosophers, one will find a commonly held assumption, which I will refer to as *the completeness of physics thesis.* Contrary to philosophical consensus, in this paper, I will argue against the completeness of physics thesis to the extent that we have good (though not conclusive) reason to question the completeness of physics thesis.

The structure of the paper is as follows: I will first identify the completeness of physics thesis as a claim which holds that all determinative entities are physical entities.[2] After having identified the thesis, I will then argue against the completeness thesis by looking at the higher sciences, in particular molecular chemistry, to provide counterexamples to the completeness of physics thesis. Furthermore, I will suggest that these counterexamples provide further support for a conditional view of nature, which is a view concerning the different ways entities display determinative powers in the world.

2. What does it mean to say that physics is complete?

As I mentioned in the introduction, the completeness of physics thesis is a widely held assumption among contemporary philosophers. But, as it is often the case, just because it is a widely held view among philosophers this doesn't mean that there is a clearly articulated thesis.

[1] Fodor (2007)
[2] The term 'entities' could be construed to denote properties, laws, and the like. But, here I will be using it more broadly. Perhaps, it best to view the term simply as referring to 'things in the world'.

The completeness of physics thesis is a case in point. Therefore, in this section, I will set out to carefully articulate the completeness of physics thesis. I will do this by first identifying common misconceptions concerning the completeness of physics thesis. After having set aside these misconceptions, I will offer my positive proposal.

What does it mean to say that physics is complete? Common responses one might hear could be "Everything is physical!" or "Everything can be described by physics!" These common suggestions reveal two views, albeit misguided views, concerning the completeness of physics thesis. For our purposes here, it will be helpful to examine them both in turn to reveal why these characterizations are wrong and misleading.

2.1 Common Misconceptions

Our first task at hand is to identify common misconceptions concerning the completeness of physics thesis. To begin with let's consider the claim which maintains that what it means to say that physics is complete is to say that everything is physical. This type of claim is often associated with the position of "physicalism" which is often confused with the completeness of physics thesis. Hence, for the purposes of this paper, I will like to keep these two positions distinct. Though, physicalism often presupposes the completeness of physics thesis, strictly speaking, the completeness of physics thesis is not about the claim that everything is physical.

Furthermore, it is consistent for one to be against the completeness of physics thesis and still agree that everything is physical. Despite want some may think, denying the thesis does not entail denying that everything is physical. My denunciation of the complete of physics thesis is perfectly compatible with Jerry Fodor's *generality of physics thesis* which states that all "events which fall under the laws of any science are physical events and hence fall under the laws of physics."[3] Notice that the generality of physics thesis is neutral in respect to completeness.

[3] Fodor (1974)

Lastly, let's return to the other misconception concerning what the completeness of physics thesis is supposed to be. Some suggest the completeness of physics thesis amounts to being able to describe everything in the language of physics. However, formulating the completeness of physics thesis as such would be incorrect, because the completeness of physics thesis is best construed as an ontological claim concerning the nature of the world, as will become more evident in the next section. The thesis is not, as we will see, about being able to describe everything with the predicates of physics, but rather, the completeness of physics thesis is about the causal (determinative) structure of the world.

To be clear, the completeness of physics thesis is an ontological thesis, but as it will become more evident it is not primarily an ontological thesis about everything but rather it is a primarily an ontological thesis about there being only one kind of determinative entities. In the next section, I will spell out in more detail the kind of determinative entities the completeness of physics thesis is about, namely physical entities.

2.2 The Completeness of Physics Thesis

In this section, I will offer my formulation of the completeness of physics thesis:

Completeness of Physics Thesis: All determinative entities are physical entities.[4]

This is the thesis I will argue against. However, one can find other different formulations of the completeness of physics thesis offered by various philosophers. So it might be helpful to review some of their proposals before turning to the evaluation of my positive proposal, which I will do so in the next section, but before turning to that I shall first briefly explain what I mean by the term 'determinative entities' which has appeared earlier in this paper and in my explicit formulation of the completeness of physics thesis.

[4] Here the term 'determinative entities' simply denotes entities that 'make things happen' in the world.

There are two ways in which an entity can be determinative, which most philosophers have missed.[5] For an entity to be determinative it can either:

(i) Contribute its own powers.

(ii) Determine the powers contributed by some other entity.

If an entity is determinative in the sense as expressed in the first instance, I will refer to it as being *strongly determinative*. And, if an entity is determinative in the sense as expressed in the second instance, I will refer to it as being *weakly determinative*.[6] Philosophers have often blindly assented to looking at only one type of determinative powers possessed by entities, in particular they have only examined the possibility that entities are strongly determinative, but there are two ways that entities can possess determinative powers.[7]

Also, I will maintain that the examples from molecular chemistry, we will examine, may provide us with reason to believe that all physical entities are captured by (i) and all non-physical entities are captured by (ii) to the extent in which they display determinative powers.[8] Here the term 'non-physical entities' simply refers to entities that belong to the higher sciences (e.g. chemistry, biology, psychology). These two kinds of 'determinative roles' correspond to two different views: the simple view and the conditional view of nature.[9] The simple view rules out the possibility of (ii), but the conditional view allows for the possibility of (ii).

According to the simple view, all the determinative entities in a collection of entities include entities only from the lower sciences (e.g. physics); while, according to the conditional

[5] For a developed account see Gillett (Unpublished)

[6] Here I do not mean weakly determinative in the sense which Jaegwon Kim has identified with the following example: "For cases in which higher-level entities and their properties prima facie causally influence lower-level entities and their properties seem legion. The celadon vase on my desk has a mass of 1 kilogram. If it is dropped out the window of my second floor office, it will crash on the paved sidewalk, causing myriads of molecules of all sorts to violently fly away in every which direction. Even before it hits the ground, it will cut a rapid downward swath, causing all sorts of disturbance among the local air molecules. (1999, 25-26).

[7] If the term 'determinative' appears without a modifier, then the term is assumed to cover both (i) and (ii).

[8] If this distinction does hold, then one could also refer to all physical determinative entities as fundamental entities in the sense that all physical determinative entities are strongly determinative.

[9] See Gillett (Unpublished)

view of nature, all the determinative entities in a collection of entities include entities from both the higher and lower sciences (e.g. physics and chemistry). The conditional view of nature is a more sophisticated view than the simple view of nature, because it allows for the possibility of some entities determining the powers contributed by some other entity. Furthermore, the conditional view allows for the possibility that, though in a sense everything is physical, there are physical and non-physical determinative entities.

Lastly, with these distinctions in place, in particular the distinction between (i) and (ii), I can provide a possible and simple schema of the conditional view concerning the relationship between entities of the higher sciences and the entities of the lower sciences. Schematically speaking, psychological determinative entities (non-physical) determine the powers contributed by biological entities; biological determinative (non-physical) entities determine the powers contributed by chemical entities; and chemical determinative (non-physical) entities determine the powers contributed by physical entities.

Assuming that only physical determinative entities contribute their own powers, this simple schema reflects the conditional view of nature and the possible relationship between scientific entities being strongly determinative and weakly determinative. Though, I recognize that may be other ways to describe the relationship between physical and non-physical entities, for our purposes here and for reasons that I will explain in later sections, I will rest content with the schema explicated above.

2.3 Possible Formulations of the Completeness of Physics Thesis

At this stage, having introduced my proposal of the complete of physics thesis, it might be helpful to pause and examine some other formulations and see why my proposal is an improvement over them. Consider the following examples:

> The domain of the physical is causally closed, which means that all physical effects have sufficient physical causes.[10]
>
> All physical events are determined… entirely by prior physical events according to physical laws.[11]

There is a common thread throughout all these various formulations. They all have the characteristic feature of being about the causal structure of the physical world. They all express the basic idea that all physical causes completely suffice for physical effects, and anything having physical effects must itself be physical. The physical can only be affected by the physical. Hence, the physical is closed from any non-physical influence.

The reason why I prefer my former formulation over these latter formulations is due to the fact that the formulations provided by Papineau and Spurrett, for the most part, rely on notion of causation that focuses on only one kind of causation (determination), which can be captured by our earlier distinction of entities being strongly determinative. However, we have recognized that there is more than one way for an entity to be determinative, hence the completeness of physics thesis needs to be formulated in order to captured these entities as well.

According to my formulation, all determinative entities are physical entities which rules out both strong and weak non-physical determinative entitles. The other formulations, provided by Papineau and Spurrett, fail to realize the possibility of another, yet legitimate, kind of determination— weak determinative entities. These formulations are not strong enough. The completeness of physics thesis needs to rule out both strong and weak non-physical determinative entities.

2.3 Premise Version

[10] Spurrett (1999)
[11] Papineau (1998)

In this section, I will briefly present the main argument of the paper in premise form, before turning to the support for the main premise of the argument. We can put the argument, *the conditional view argument***,** in the following premise form:

> (P1) If the completeness of physics thesis is true, then there are no non-physical determinative entities.
>
> (P2) It is not the case that there are no non-physical determinative entities.
>
> (C3) Therefore, it is not the case that the completeness of physics thesis is true.

The name of the argument comes from our earlier distinction between two possible ways to view determination in nature. Recall, there's the simple and the conditional view of nature. Since, the argument lies within the spirit of the conditional view of nature it has been named after it. In the next section, I will examine the support for (P2) in detail.

3. The Case from Chemistry: The Plurality of Determinative Entities

I shall now turn to examples from the higher sciences, in particular molecular chemistry, to provide examples of non-physical determinative entities and to further provide support for the conditional view of nature.

As we begin, it is important to remember, as I mentioned in the introduction, my argument is an argument against the completeness thesis to the extent that we have good, but non-conclusive, reason to question the completeness thesis. I look to the evidence, at the very least, to establish the beginnings for the position that there exists non-physical determinative entities. My purpose here is only to provide *prima facie* support for the conditional view of nature and support for the plurality of determinative entities.

3.1 Preliminaries

It is important to recognize, as we work through the cases from molecular chemistry, that chemists and philosophers interested in chemistry, for one reason or another, often operate under

premature theoretical frameworks. So, when they speak of "the unpredictability of chemistry", "the irreducibility and nonderivability of the chemical to the physical", "downward causation", or "the inability of physics to explain and describe molecular structure", we need to often charitably reinterpret them in order to extract the important insights about the possibility of non-physical determinative entities. Though some of the examples from molecular chemistry are more apt for supporting predicate indispensability arguments, there are others that provide support for the existence of non-physical determinative entities, or so I will contend.

In examining whether or not non-physical determinative laws exist I shall turn my attention to examples from molecular chemistry. Though these examples are commonly thought to provide instances of 'downward causation', again, it is best to interpret them as instances of downward determination that involve non-physical entities that are weakly determinative.

The reason for this is as follows: the term 'causation' usually refers to a kind of determinative relationship, in particular that of being strongly determinative, that is best reserved for the lower level scientific entities (e.g. physics).[12] However, since we have seen that there are two ways for an entity to be determinative (e.g. strongly determinative and weakly determinative) it is misleading to call these instances of 'downward causation'. This is why it is best to call these instances from molecular chemistry cases of 'downward determination'.

Another question that may appear at this point concerns how one should identify non-physical determinative entities. To clarify, this question is about how we should separate physics from, say, chemistry, and biology given the fact that, in a sense, everything is physical. I shall recommend one suggestion: probably the best way to identity the physical from the non-physical would be to turn to the actual scientific examples, which I will do so in a moment. One can

[12] I will not go into the details here concerning why I believe this to be the case, but I will mentioned that some of the reasons behind claiming that strong determinative entities are only entities from the lower sciences are due to concerns of over-determination and problematic ontological consequences.

identify the non-physical by examining a higher science such as chemistry, and, in particular, molecular chemistry.

Lastly, there is a sense which higher science entities are irreducible which won't pose a problem for the completeness of physics thesis, as long as these entities are not determinative and irreducible, but if it turns out that these entities are determinative as well as being irreducible then this is a conclusion that defenders of the complete of physics thesis would be motivated to resist. Again, it's not an issue of definability, predictability, or mere derivability of the higher sciences entities from the lower sciences entities, which is a mistake many have made in the past, but rather it is an issue about the ultimate determinative constituents of the world.

In the next section, by examining molecular chemistry, I will argue that it is plausible to maintain that the organizational and configurational arrangement of molecular structures play weak determinative roles, while, at the same time, whose determinative roles are not captured by physics. The structural arrangement of molecular structure occurs at the chemical level, and not the physical level. In this case, chemical entities and not physical entities, explain molecular bonding and their determinative powers upon the physical.

3.2 Turning to the Cases

As we finally turn to some examples, I will try to explicate the claim that molecular structures display "novel causal properties" and the claim that these "properties are irreducible to the causal efficacy of lower-level properties."[13] As it has been emphasized numerous times, this search for "novel and irreducible causal properties" is really the search for non-physical determinative entities and so I will turn my attention to that. Molecular structure, the particular shape or arrangement of particular atoms, provides examples of non-physical determinative entities. In particular, I will argue that molecular isomers and molecular chirality.

[13] Bishop (2005, 715)

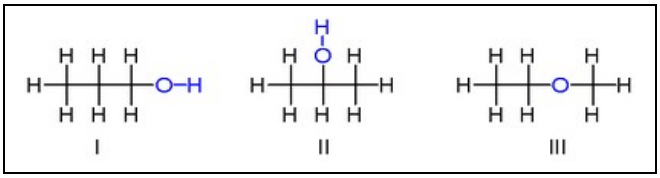
3.3 Molecular Isomers

Molecular isomers display the crucial determinative role concerning the influence of lower level entities. Molecular isomers are compounds that have the same molecular formula but different structural formulae. Robert Woolley writes:

> The development of quantitative methods of chemical analysis in the nineteenth century led to the realization that it is possible for two or more compounds to possess identical chemical compositions, and yet to be quite different in some or all of their chemical and physical properties.[14]

What accounts for the differentiation of molecular structure, as I shall argue, are non-physical (chemical) determinative entities. Molecular isomers challenge the simple view of nature.

It is not simply the mere simple collection of molecules that play a determinative role in the lower sciences, but actually the specific arrangement and position of the molecules themselves that play the determinative roles, thus this supports more of a conditional view of nature. Moreover, if this is the case, then this challenges the thesis that all non-physical entities are determinative entities, because we have just seen the possibility of chemical entities playing a crucial determinative role. For further explanation, consider the below diagram of a simple example of isomerism:



In the diagram, all three have the same chemical formula C_3H_8O, but their structural arrangements result in three different substances. So, they contribute different properties, and hence different determinative powers. Model I is propan-1-ol, model II is propan-2-ol, and model III is methoxyethane. Model III, in particular, has significantly different properties from Model I

[14] Woolley (1976, 28)

and Model II. For example, on the one hand, Propan-2-ol is rubbing alcohol; and, on the other hand, Methoxyethane is colorless gaseous ether.

3.4 Over-Determination?

The principle of over-determination maintains that there cannot be two sufficient causes for the same physical event. Some may argue that viewing molecular isomers as weak determinative entities would violate this principle. I disagree; the existence of isomers seems to suggest that the higher sciences contain some entities that 'push-around' the entities of the lower sciences entities in a determinative manner that respects the principle of over-determination.

Though I find this principle suspect, for our purposes here and for the sake of argument, I will assume that the over-determination principle is correct, and argue that non-physical determinative entities do not violate the over-determination principle. For example, if the molecular structure that corresponds to Model III does not obtain, then there would be no downward determination to result in the properties of being a colorless gaseous ether, and hence no over-determination.

Recall the earlier made distinction between being strongly determinative and weakly determinative. Since the molecular structure, of Methoxyethane, determines the powers contributed by some other entity, instead of directly contributing its own powers there is no need to worry about over-determination. It is wrong to view different kinds of determinative entitles as competing with one another. Rather, it is best to view them in a concerted effort to bring about physical effects in the world.

Woolley writes, "Irrespective of the kind of description employed, isomerism can be recognized as evidence of the greatly enhanced diversity of behaviour that occurs in 'large' dynamical systems, and which is absent in small ones."[15] The properties contributed by

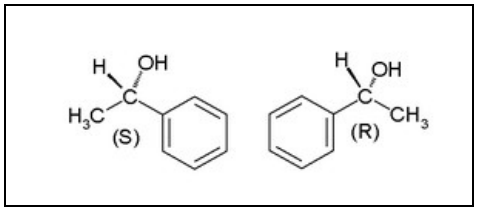
[15] Woolley (1976, 47)

molecular chemistry can not be explained or captured by physics, in particular physical determinative entities. Chemical determinative entities can, so to speak, 'push-around' entities from the lower sciences. Let's now turn to a similar, yet distinct, molecular concept in order to further explicate the support for the existence of non-physical determinative entities.

3.5 Molecular Chirality

We have just examined molecular isomers which demonstrated the possibility of chemical entities contributing determinative powers. We shall now turn to a similar, but distinct chemical concept, to demonstrate, once again, the possibility of non-physical (chemical) determinative entities. I will take my cue from Robert Bishop. Consider the example provided by Bishop: "A well-known example is different enantiomeric species of chiral molecules, whose chirality (handedness) is not a relevant observable at the level of quantum mechanics."[16] Non-physical determinative entities can be found in the molecular concept of chirality.

In the context of chemistry, the term 'chiral' or 'chirality' is used to describe a molecule that is non-superposable on its mirror image. In particular, chiral molecules are referred to as enantiomers. See the below diagram for an illustration of molecular chirality:



In many ways, chirality is a further extension of molecular isomers. Chirality is an example of downward determination, because the mere difference in 'handedness' of the molecules results in the determination of different properties among the entities of the lower sciences.

The downward determination of molecular chirality can often be seen in the devastating physical consequences. For example, Robert Bishop writes, "Molecular chirality (handedness of

[16] Bishop (2006, 1765)

molecules) led to disaster in thalidomide-based treatments in the 1960s, because one species of handedness was harmful while the other was beneficial".[17] One prevents morning sickness, the other one results in birth defects.

In terms of downward determination, chiral molecules, besides the opening remarks of the efficacy of molecules for thalidomide and other diseases, "are crucial for the explanation of optical activity… interpretations of single Biomolecule spectroscopy and in the nanomechanical properties of molecules."[18] Here are other examples of molecular structure in which chirality plays a crucial determinative role. The determinative roles of chirality can be seen in the explanation and determination of properties such as optical activity and thalidomide. Molecular structure, in particular molecular chirality, has a determinative affect on the entities of the lower sciences.

4. Conclusion

In this paper, I have presented an argument against the completeness of physics thesis. The completeness of physics thesis maintains that all determinative entities are physical entities, but I have argued that there is good *prima facie* reason to think that the completeness of physics of thesis is false. Drawing from molecular chemistry, I have suggested that there exist non-physical determinative entities.

I haven't addressed possible objections; however, remember, my purpose was not to establish a conclusive case, but rather a *prima facie* case for the possibility of non-physical determinative laws. At the very least defenders of the completeness of physics thesis need to articulate an account that explains these examples from molecular chemistry in a way that is

[17] Bishop (2005, 712)
[18] Bishop (2006, 1765)

compatible with the completeness of physics thesis and perhaps the conditional view of nature as well.

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