What has Science told us about Materialism?

The aim of this paper is to consider some examples from well established sciences in order to see what science has told us about materialism. The hope is that by examining some uncontroversial examples we will be able to obtain some principles that can be applied to the tricky case of the mind. We will see that both water and superconductors are mereologically emergent; the organised whole can do things that the parts can't. But they are mereologically explicable; it is possible to explain the nature of the whole in terms of the parts. There are two main conclusions we can draw from these examples. First of all, a strongly eliminative materialism is false. Secondly, if the mind is emergent in the same way as water and superconductivity, then a lot of the current debate about the metaphysics of mind is beside the point.

The debates within philosophy of mind between the dualist and materialist and between reductive/eliminative and non-reductive/emergent[1] materialists are hotly contested (Bechtel & Richardson 1992; Bickle 2001; Chalmers 1996; Churchland, P.M. 1996; Churchland & Churchland 1994; Churchland, P.S. 1996; Craver & Bechtel 2007; Fodor 1989, 1997; Horgan 1997; Jackson & Pettit 1990; Kim 1993b; Le Pore & Loewer 1987, 1989; Ludlow et al. 2004; Marras 2007; McGinn 1997; Pereboom 2002; Van Gulick 2001; Yablo 1992). But the debates are hard to adjudicate because there is great disagreement about the foundational issues. Is it necessary for our mental theories to be unrelated or irreducible to our neurological theories in order for the mind to be emergent? Can the mind be physical and still possess its own unique causal powers? What is it for something to be physical in the first place? The debates are further complicated by the relatively undeveloped nature of the scientific study of the mind. It is hard to use the scientific data as a guide when the science is so young and diverse. The goal of this paper is to step away from the controversial case of the mind and examine what is going on in two examples that concern obviously physical things: water and superconductivity. The hope is that by seeing what is going on in these simple examples we can get a better sense of the relevant issues. More importantly, perhaps some of the disagreements about the foundations can be answered, at least for these cases. We will see that water and superconductivity are ontologically distinct from their molecular components even though their natures can be explained in molecular terms.

In the first section I will characterise the point of disagreement between the eliminative and emergent materialists. In the second section I will consider the examples of water and conductivity to see whether they vindicate

[1] I prefer the term emergent materialism because 'reduction' is often used to characterise the relation between theories. As we will see, the metaphysics and theoretical relations between parts and wholes can come apart. Note that 'emergence' has historical connotations of inexplicability (McLaughlin 1992). I am not using the word in this sense. We will see that emergent phenomena are mereological explicable and that mereological explicability is what distinguishes emergent/non-reductive materialism from property dualism.

eliminative or emergent materialism. In the third section I will show how the emergent materialism supported by the examples is distinct from property dualism. In the final section I will argue that if the mind is emergent in the same way as water and superconductivity then a lot of the debate regarding the mind is beside the point. We will see that science has told us that emergent materialism is true because organised wholes can have causal powers that their parts lack even though it is possible to explain the nature of the whole in terms of its parts.

1. Eliminative and Emergent Materialism

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Although ultimately the answer to foundational questions will be answered by looking at the examples, we need to look briefly at the foundational issues so we can understand what questions we are asking of the examples. Water and superconductivity are uncontroversial physical. So the point of examining water is not so much to adjudicate between the materialist and the dualist[2] as it is to examine the materialist alternatives. The main bone of contention between materialists is whether emergent or eliminative materialism is true. We will see that eliminative materialism is false if the putative higher-level phenomena have causal powers that their parts lack.

Materialists accept that everything is physical. Part of what this means is that they accept that everything is constituted by the entities of microphysics. In other words at the heart of all forms of materialism is a denial of substance dualism. The substance dualist claims that there are two fundamental types of substance in the world, the physical and the non-physical (usually the mental). When contrasted with substance dualism, materialism is usually taken to be a form of monism – the materialist is seen as claiming that ultimately there is only one type of substance: the physical. I want to suggest that conceiving of materialism as monism is too restrictive. To take a toy example, if the ultimate constituents of everything were protons, neutrons and electrons, it seems that there is a real sense in which materialism would still be true. What matters for the materialist is not so much that there is *one* fundamental thing, but that there is a fundamental set of things, all of which are within the reach of microphysics. It is only if there are ultimate constituents which are not within the reach of microphysics, that it seems sensible to classify the position as a form of substance dualism (see for instance Chalmers 1996). What materialism requires is not so much monism as "(micro)physics foundationalism"[3]. The basic entities, however many there are, all need to be within the reach of microphysics.[4]

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[2] Although see below for a discussion of the difference between emergent materialism and property dualism

[3] Thanks to Jon Opie for suggesting this terminology.

[4] One notorious problem for materialism is whether the physics appealed to in the definition of materialism is current physics or complete physics. If materialism is defined in terms of current physics then, given that current physics is almost certainly false, materialism will also be false. But if it is defined in terms of complete physics then, given that we have no idea of what complete physics will be like, the position becomes so vague as to be almost vacuous. I think Sober's response to this dilemma is appropriate:

> The right response is simply to admit that we know how to apply the concepts of mental and physical property only in so far as the properties in question resemble those that we currently call mental and physical. If future science departs

Where the debate lies between the forms of materialism is not over the nature of the basic constituents but rather about whether there is more than the basic entities of mircophysics. In particular what is at issue is the relation between the apparently more complex things and the basic entities of microphysics. Is materialism strongly eliminative – is everything nothing but the entities of physics? Or can materialism countenance the existence of emergent phenomena – is there more to the world than the entities of microphysics? The strongly eliminative materialist presents a flat ontology in which everything is nothing but the entities of microphysics. The chair on which I sit, the computer on which I am typing and my colleague next door, are all nothing but sub-atomic particles. On this view, even the more complex objects that physics deals with, such as atoms or molecules, would be nothing more than the entities of microphysics. For the strong eliminativist, the only level in our ontology is the level of basic microphysics. On such an account, everything is physical in that everything is the entities of microphysics. For the stong eliminativist, the complexity we see in our world is apparent and the entities of microphysics are all that really exists. The emergent materialist views the complexity as real. For the emergent materialist the world is layered and there is more to the world than the basic entities of physics. The chair on which I sit on is composed of the entities of microphysics, and it is physical, but it is somehow more than its microphysics constituents. For the emergent materialist the novelty we see in our world is real and physical. There is more than the entities of microphysics but it is still all physical. The question is: How can we decide if science supports reductive or non-reductive materialism? How can we tell if the complexity is real?

What we need is a criterion for determining whether a whole is distinct from its parts. In particular, if we are to show that emergent materialism is true we need a criterion that is sufficient for showing that two phenomena are ontologically distinct. On what basis would we want to say that the whole is novel and metaphysically distinct from its parts? In fact, on the basis of what would we want to add *anything* to our ontology? Kim's suggestion that to be real is to have causal powers is prima facie plausible:

> For something to be real is for it to posses causal powers (let us call this "Alexander's Dictum"); mere epiphenomena have no causal work to do, and their existence makes absolutely no difference to the rest of what exists – they might as well be "abolished" (Kim 1992 pg 134)

This principle, named after one of the more prominent British Emergentists, certainly seems to capture a sufficient condition for entry into our ontology.[5] In

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> dramatically from current conceptions, it may be impossible to say whether that science ends up vindicating or overturning what we now call physicalism. However this possible indeterminacy does not deprive physicalism of its philosophical interest. There is still a point to the question of whether psychological properties, as we currently understand them, supervene on physical properties, were the latter are understood in terms of our current best physical theories (1999 pg 136)

[5] Note that it is far from clear whether it is *necessary* for a higher-level phenomenon to have its own unique causal powers in order for it to be real (Churchland & Churchland 1994; Dretske 1990; Fodor 1989; 1997; Heil & Mele 1991; Horgan 1997; Jackson & Pettit 1990; Jones 2004; Kim 1992, 1993a, 1994; Le Pore & Loewer 1987; 1989; Lowe 1993; Van Gulick 1993; Yablo 1992). The crucial point to note is that I am not claiming that Alexander's dictum

particular both common sense and scientific methodology suggest that it is sufficient. If I suggested that there really are fairies at the bottom of my garden, and went on to provide evidence in the form of footprints, houses, video recordings and direct observation then the sensible but surprising conclusion would be that there really are fairies. If we could see that the fairies were doing, were having an effect on the world, it would be hard to deny that they are real. The observation and experimental manipulation of the world that are at the heart of the scientific methodology also seem to involve a commitment to Alexander's dictum. For example, geologists ultimately admitted that continental drift occurs because there was a complex pattern of effects that could best be explained by the hypothesis that the continents are moving (Kitts 1977; Laudan 1978; Marvin 1973). Because of the match with both every day and scientific practice it seems plausible to accept Alexander's dictum as a sufficient condition for existence.[6] To show that something is real, all we need to do is to show that it does something.

Given that having causal powers is sufficient for something to be real, it seems that a mark of ontological difference is having a different type of causal power. That is, we could say that a complex whole is distinct from its parts if the whole has a different type of or collection of causal power(s) to those had by its parts. Note that it is important that the difference in causal powers be qualitative, not quantitative (Auyang 1998). For example, it seems appropriate to say that although a grain of sand and a pile of sand have different causal powers (only the latter could move a balance beam that has an apple on the other end); they nevertheless have the property of having a mass in common. This difference in causal powers is quantitative not qualitative. They have the same type of causal power, just different magnitudes of it. It seems that it is only if the complex whole can do a distinctive type of thing that we are warranted in concluding that it is ontologically distinct from its parts. So, what we need to do in looking at water and superconducicitivty, is to see whether the organised wholes can do different types of things to their parts. We will see that water and superconductivity are clearly emergent and that stronlgy eliminative materialism is clearly false.

2. The Examples

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presents a necessary criterion. What we need for our current purposes is not the necessary conditions, but a sufficient condition. What is sufficient to show that the whole is more than its parts?

[6] Note that it is one thing to find a causal power; it is another to attribute it to a particular phenomenon. In order to determine what is responsible for a causal power it may be necessary to adopt a condition that is more complex than simply the idea that to be real is to have causal powers. In particular, it may be necessary to go for something more like Wimsatt's notion of robustness: 'things are robust if they are accessible (detectable, measurable, derivable, producible, or the like) in a variety of independent ways' (Wimsatt 1994 pg 210-11). All of the examples I will be dealing with here are part of very well established scientific theories, and presumably have achieved this status because they are robust. Thus, for the sake of simplicity I will stick with the simpler notion, namely Alexander's dictum.

2.1 Water[7]

One of the most popular examples of an identity is that of water and H_20. Although it is undeniably correct to say that water is composed of H_20 molecules, when we examine the relation in more detail, it becomes apparent that the slogan "water is H_20" is an oversimplification. In particular, if we take possession of distinct types of causal power as an indication that there are different phenomena, then it becomes clear that water is novel and distinct from H_20 molecules. Nevertheless, it is possible to explain the properties of water in terms of the nature of the H_20 molecule.

The term "water" is vague. First of all, just about everything we call "water" contains particles besides H_20. So we need to talk about "pure" water.[8] But this is a trivial complication compared to that which arises from the fact that "water" has many different states. Does "water" refer to the liquid, solid, gaseous or crystalline versions of H_20? This is a particularly relevant question given our focus on causal powers, because "water" in these different states has different types of causal powers. Whether the "water" is liquid, solid or gaseous matters very much to the person about to leap off the diving board. Given that in ordinary usage "water" usually refers to "liquid water"[9] the most charitable reading seems to be to take "water" in the purported identity to be referring to the liquid.

The term "H_20" is as vague as the term "water". Does "H_20" refer to an individual molecule or a group of molecules (say a mole or (roughly) $6x10^{23}$ H_20 molecules)? If it refers to an individual molecule then the identity is false – an individual molecule is not a liquid. So water is not identical to an individual H_20 molecule. But it is not simply enough to specify the number of molecules. If the molecules were evenly distributed throughout the universe they would not form any macro-substance whatsoever. So water is not identical to a collection of H_20 molecules. Even if we specify that the molecules are in close quarters, say within a region with a volume of $50cm^3$, we still have not fixed the causal powers of the system. One mole of H_20 molecules could be a gas, a liquid, a solid or a pile of snowflakes. At different temperatures and pressures the H_20 molecules will be in different states. At 1atm of pressure and 25^oC, 1 mole of H_20 molecules is a liquid. But at 1atm of pressure and –10^0C, the same set of molecules will be a solid and at 0.01atm of pressure and 25^0C the same set of molecules will be a gas. In other words, the one set of H_20 molecules can be a liquid, solid, gas or vapour. Most importantly in these different states the H_20 molecules will have different causal powers: you can't swim in ice or drink steam.

The point of this is not to criticize those who simply talk about water being H_20 for being sloppy. I am not claiming that anyone who talks about water being H_20 is ignorant of the fact that this is an oversimplification and that a more accurate identity would be something like "16ml of pure liquid water is $6x10^{23}$ H_20 molecules in close quarters at 1atm pressure and 25^oC". Rather my point is that writing the short-hand version is misleading because it

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[7] This example is taken from Bunge (1979) and Auyang (1999)

[8] And even "pure" water contains H^+ and OH^- ions.

[9] According to the OED definition 'water' is 'The liquid of which seas, lakes, and rivers are composed, and which falls as rain and issues from springs. When pure, it is transparent, colourless (except as seen in large quantity, when it has a blue tint), tasteless, and inodorous' (Oxford-English-Dictionary 2006).

masks the fact that the arrangement of the H_20 molecules is crucial in determining the nature of the system of molecules. One mole of H_20 molecules can burn or soothe a burn depending on how they are arranged. Similarly it was a group of H_20 molecules that assisted the Titanic to sail halfway across the Atlantic and it was also a group of H_20 molecules that tore a hole in the side of the ship causing it to sink. If the causal powers of a group of H_20 molecules were not dependent on more than the fact that their constituents are H_20, then these differences in causal powers would be paradoxical. If the only determinant of the causal powers of ice and water was the nature of their constituents, then given that they have identical constituents, water and ice would be identical (Auyang 2000). But this is obviously false. Water and ice have different types of causal powers. The fact that the same constituents can form different complex phenomena that have different types of causal powers means that the complex phenomena can not be identical to their constituents. There must be more to being water, snow, or ice than being composed of H_20 molecules.

This means that water is mereologically emergent. It cannot be identified with its micro-constituents because the same micro-constituents can form a different macro substance. An organised collection of H_20 molecules can have a different type of causal power to that of its constituent molecules and to those possessed by the same set of molecules in a different organisation. So water is not nothing but its micro-constituents. Water cannot be eliminated from our ontology in favour of its micro-constituents.

Nevertheless it is possible to explain the nature of water in terms of the nature of its constituents.[10] Water has a number of unusual properties; for example the liquid form of water is denser than the solid (so ice floats in water). Water also has unusually high boiling and melting points. The source of these unusual properties can be traced to the hydrogen bonds that form between H_20 molecules. Hydrogen bonds are unusual because they are significantly stronger than other inter-molecular forces. This means that the molecules within water are held together more strongly than the molecules of similar substances whose molecules do not form hydrogen bonds. The fact that ice is less dense than water can be explained in terms of the geometry of ice in comparison to water. At low temperatures, each oxygen atom is surrounded by four hydrogen atoms, two of which it is covalently bonded to and two of which it is bonded to via hydrogen bonds. The result is that the molecules form a three dimensional structure. This structure is quite rigid such that the molecules are prevented from getting close to each other. As a result of these large gaps between the molecules, the density is low. As the temperature increases, the kinetic energy of the molecules increases, on average. Some of the molecules have enough kinetic energy to pull free of the intermolecular hydrogen bonds – it is like they are jumping up and down too fast to be able to hold hands any more. As the ice begins to melt, these molecules which have broken free of the hydrogen bonded structure become trapped in the cavities of the there-dimensional structure. The result is that there are more molecules per unit volume in liquid water than in ice. So cold water is denser than ice, such that ice floats on water.

[10] The details of this explanation are taken from Atkins and Beran (1989).

As this example indicates, it is possible to explain the nature of water in terms of the nature of its atomic (and its subatomic) constituents. We can (roughly)[11] explain the properties of groups of H_20 molecules in any state in terms of the properties of the H_20 molecule. Water is mereologically novel, yet its nature can be explained in terms of its parts. This pattern, of explicable mereological novelty, can also be found in physics.

2.2 Superconductivity[12]

Superconductors provide us with another example of explicable mereological novelty (Auyang 1998). Conductors and superconductors both have electrons that are free to move throughout the substance. Usually the electrons move in different directions such that the net current is zero. However when a voltage is applied across the substance, the electrons move in the same direction and this generates a macroscopic current. Even the best conductors have some resistance – if the driving force is turned off the macroscopic electric current decays and finally vanishes. This is because the electrons lose energy in the form of heat by bouncing off impurities or particles in the crystal lattice. In contrast to conductors, superconductors have a resistivity of zero – the current in a superconductor never dies out. We will see that when in the superconducting state the substance can do things it cannot do in other states, but it is possible to explain this new type of causal powers in terms of the constituents.

The first thing to appreciate about superconductors is that when in the superconductive state, the metal has a different type of causal power to that which it has at higher temperatures. At room temperatures[13] the metals that are superconductors, such as aluminium, mercury and lead, are standard conductors. That is, exactly the same set of atoms can be either a conductor or a superconductor (Auyang 1998). When electrons are placed in a cold crystal lattice they are able to do things as a group (conduct with a zero resistivity) that the same electrons, in the same crystal lattice, at a higher temperature cannot. The fact that the same set of constituents can have two completely different types of causal powers indicates that there is more to the metals possessing those causal powers than the nature of their constituents. Otherwise the difference in causal powers despite the identity of the constituents would be impossible. So, as with water, superconductivity cannot be eliminated from out ontology. It is different from its micro-constituents.

Although there is more to being a superconductor than just having a particular type of microconstituent, superconductivity can nevertheless be explained in mereological terms. Superconductivity arises because of the collective action of the conducting electrons. The electrons interlock to move in concert, thereby avoiding collisions and the associated loss of energy. The basis of this interlocking is the interaction between pairs of electrons. In type

[11] In fact we still lack a precise model of liquid water that can account for all of its anomalous properties. Although different models can account for different properties no model can account for them all (for more details see Chaplin 2005; Guillot 2002)

[12] Unless otherwise indicated, the material in this discussion of superconductivity comes from Tipler (1991). Note also that there are actually two types of superconductors. I will focus on type one superconductors as the micro-mechanism for them is relatively well understood.

[13] Type one superconductivity only occurs at temperatures close to absolute zero. For example aluminium is only a superconductor at temperatures below 1.14 K and lead at 7.19K (Tipler 1991 pg 1313)

one superconductors, the electrons are able to avoid collisions because they move through the lattice in pairs with one electron riding in the “slip stream” of positive charge created by the passage of the first. The first electron moves through the lattice and distorts it by attracting the positively charged atoms towards it. This creates a trough of positive energy into which another electron is drawn, before the atoms move back into their normal position. The distortion of the lattice means that electrons, which would usually repel each other, travel in pairs, called “Cooper pairs”. These Cooper pairs interlock to form a pattern spanning the whole superconductor. The interlocked electrons do not scatter, and move coherently as a unit (Auyang 1998 pg 180). Keeping things cool is important because it reduces the molecular motion - when the temperature is raised and the lattice vibrates more, the electron pairs (and therefore the interlocked network of electrons) are broken apart.

What we can see is that there is more to being a superconductor than having certain types of constituents, yet superconductivity can be explained in mereological terms. If you take certain metallic crystal lattices and cool them down, then they can do a different type of thing to what they can do at higher temperatures. We can understand how these organised structures can do things at low temperatures that they cannot do at higher temperatures in terms of the nature of their constituents. Superconductivity provides another example of a complex phenomenon that has a different type of casual power to its parts, and yet can be explained in mereological terms. In the next section I will consider what this pattern, of explicable mereological novelty, tells us about the nature of materialism

3. Distinguishing Emergent Materialism from Property Dualism

It appears that radically eliminative materialism is false. It is wrong to say that there is nothing but the entities of microphysics because when they are arranged in the right way, they can do different things. Organised wholes have causal powers that their parts lack. These examples support physics foundationalism, water and superconductors are ultimately made out of the entities of micro-physics. There is no extra mysterious substance (Auyang 1999 pg 7). However there are higher-level causal powers that are not causal powers of physics stuff. So in what sense are these emergent phenomena physical? How is emergent materialism distinct from property dualism? In order to answer these questions it is necessary to consider the explanatory relations between the emergent phenomena and their parts.

Like the materialist, the property dualist accepts that everything is constituted by the entities of microphysics. That is, the property dualist accepts physics foundationalism. However, the property dualist claims that these fundamental physics entities have non-physical properties. Defining “physical property” is no easier than defining “physical”. However, I suggest that an examination of the history of science supports the view that obtaining a mereological explanation of a phenomenon is sufficient for us to accept it is physical. Consider life. At one point in time, vitalism was popular. Vitalism is the idea that the property of being alive is a non-physical property and that what turns inanimate matter into animate matter is the presence of a non-physical vital spirit (Robinson 2006). However, as biology progressed and we obtained a micro-explanation of life, vitalism fell out of favour. As we began to see how to build living organisms out of chemical and ultimately microphysics entities, we moved from thinking that the property of being alive was non-physical to accepting that the property of being alive was physical. In other words, obtaining a mereological explanation vanquished a property dualist account of life.

This reflection on the rise and fall of vitalism suggests that the property dualist claims that some properties are 'nonphysical in the sense that they cannot ever be reduced to or explained solely in terms of the concepts of the familiar physical sciences' (Churchland, P. M. 1988 pg 10 see also Auyang, 2000). We can also see this notion of dualism at work in the debate about consciousness. Those who argue for dualism do show by arguing that consciousness is mysterious and inexplicable in physical terms (see for example Jackson 1982, 1986; McGinn 1989; Nagel 1974, 1986, 1998). What materialism requires is that there be a "perspicuous nexus" (Cottrell 1995) between the higher and lower-levels. We need to be able to see how emergent phenomena are a result of arranging the foundational things in the right way. I want to suggest that the property dualist claims that there are properties for which no such nexus exists and that the reason why we cannot know that such properties are physical is because they are not physical. The materialist claims that there are no properties for which there is a mystery. So, in order to distinguish materialism from property dualism it is necessary to consider the explanatory relations between levels. In particular we need to consider whether mereological explanations are possible.

As we have seen in the previous section, it is possible to obtain mereological explanations of water and superconductivity. For example it is ultimately possible to get at least the outline of an explanation of the bonding properties of metals and the nature of super conduction in quantum terms.[14] Similarly the nature of water is explicable in terms of the nature of the hydrogen bonds linking the molecules together and the nature of hydrogen bonds can be explained in terms of the nature of hydrogen and oxygen (Bunge 1979 pg 42-3). In general although the whole has causal powers that the parts lack, it is possible to account for the causal powers of the whole in terms of the properties of the parts.

Interestingly, although it is possible to explain the properties of the whole in terms of the properties of the parts, the higher-level theory is still necessary. This is because the types fail to line up across levels. The one set of basic constituents can be arranged in many different ways to form many different systems with different emergent causal powers. For example one mole of H_20 molecules can be arranged in different ways to form a solid, liquid or gas. For our current purposes the important thing is that the one lower-level type can be the constituent of many different higher-level types such that the types do not line up across levels. Ontologically, the lower-level type "fragments" into many different higher-level types, this means that the lower-level theory must also "fragment" in order to capture the higher-level differences. To treat any system of H_20 molecules as the same because it has the same constituents would be to miss important differences in causal powers that arise from the different arrangements of the constituents. In fact if

[14] The limits of the explanation are more computational – the maths becomes hard – rather than theoretical. If we could do the maths we could explain it

one merely focused on the similarities in the constituents then the differences in causal powers that arise from the different possible organizations of the constituents would become inexplicable. So we need higher-level theories in that we need theories that refer to the emergent phenomena at the higher mereological.

So it is possible to get an explanatory “reduction” in the sense that it is possible to explain the properties of the whole in terms of the nature of the constituents, but we do not have an explanatory “reduction” in the sense that a theory that refers to the higher-level phenomena becomes redundant and can be eliminated. Bunge calls this “reduction without levelling”:

> Explanation has not eliminated emergent properties … In particular, it has not eliminated the emergent laws characterising such systems: indeed such emergent laws are invariant relations among emergent properties, and emergence does not go away when explained. In other words, reduction does not imply levelling, it relates levels instead of denying that they exist (Bunge 1977 pg R79).

Although there are causal powers that do not belong to the foundational physics things we can often explain how structured systems of the basic physics things are able to have causal powers that the isolated physics things lack. This means that these emergent phenomena are not ‘mysteriously emergent’ (Churchland 1984), rather they are explicably emergent. There is no mystery because we can see how the basic physics things, when arranged in the right way, can have emergent causal powers. It is this explicable emergence that distinguishes emergent materialism from property dualism. It is because we can explain the emergence of new causal powers in terms of the nature and arrangement of the parts that these emergent phenomena are physical. Water and superconductivity are explicably emergent and therefore show that emergent materialism is true. In the final section I want to take the lessons learnt from the examples and see how the impact the debate regarding the mind.

4. What have we learnt?

As noted at the beginning, one of the main places where the debate regarding materialism rages is in the philosophy of mind. I want to finish by seeing how the lessons we have learned from our examination of these simple examples can inform the debate in philosophy of mind. Three features of the debate about the metaphysics of mind stand out as being in tension with the above examples. These are: the focus on the relations between theories; the problems with causation that arise from functionalism and the focus on multiple realisability. In this final section I will look at each of these in turn.

A lot of the debate regarding the metaphysics of mind focuses on relation between neurological and cognitive theories (Bickle 2001, 2003; Block 1997; Churchland 1985; Churchland, P.S. 1988; Fodor 1989, 1997; Kim 1997; Le Pore & Loewer 1987; McClamrock 1992; Putnam 1973). The goal seems to be to show that the mind is (or is not) ontologically distinct from the brain by showing that our cognitive theories are (or are not) independent of our neurological theories. The mind must be distinct from the brain because we cannot relate our theories. The examples of water and superconductivity suggest that this is mistaken. A whole can be distinct from its parts even though it is mereologically explicable. In fact, at least for the cases of water and superconductivity, mereological explicability is crucial for distinguishing emergent materialism from property dualism. These examples suggest that in order to show that the mind is distinct from the brain, one need not focus on cognitive and neurological theories. Rather it is sufficient to show that the mind has causal powers that the brain lacks. Emergent materialism is true not because higher-level theories float free of lower-level theories, but because the whole can do things that the parts can't.

The second point of difference between the mind and the examples considered above is the appeal of functionalism for the mind and the problems this creates with causation. It seems that our best account of the mind is computational, but this seems to imply that functionalism about the mind is correct. A computer seems to be a physical system whose parts are arranged in a particular causal pattern. The problem is that Kim has long argued that the standard functionalist accounts of the mind do not put the mind at a mereolgoically higher level to its realisers and therefore do not give the mind causal powers that are distinct from its realisers. It is these arguments that have motivated the focus on theories in order to motivate explanatory relevance, not possession of unique causal powers, as the necessary criterion for ontological uniqueness. An obvious point of difference between the mind and the examples considered above is that water and superconductivity are not functional phenomena. It is not the causal relations between the parts, but their organisation, that makes the whole more than the parts. It is tempting to think that this difference means that the current examples are beside the point. However this would be mistaken. What these examples serve to highlight is the problems that functionalism about the mind causes. It is functionalism that creates the problems with mental causation and seems to make emergent materialism about the mind untenable. The examples of water and superconductivity suggest that the focus on explanatory relevance and the desire to show that higher-level theories are independent of lower-level theories is not driven by an examination of the sciences so much as a commitment to functionalism about the mind. Thus, the challenge for the emergent materialist with respect to the mind is either to find other examples from science where explanatory relevance is sufficient for emergence, or to show that the mind can be at a mereologically higher level to its parts (see Schier under review for an argument that connectionism puts content and therefore the mind at a mereologically higher-level to the brain).

The final difference between the debate regarding the metaphysics of mind and the examples considered here is that multiple realisability (MR) is irrelevant to the emergence of these phenomena. Water is not MR; there is only one set of micro-constituents (namely hydrogen and oxygen) that can "realise" water. So MR is not necessary for the emergent physical phenomena we see in the sciences. Unlike water, superconductivity is MR. Superconductivity can be realised in, amongst other thing, lead and iron. But the argument for the emergence of superconductivity was independent of the fact that the property is multiply realisable. Superconductivity is emergent because the organisation of the parts determines the causal powers of the whole, such that different organisations of the same parts can have different causal powers. In other words, to show that superconductivity is emergent we showed that the same set of parts can have different causal powers. The fact that different types of constituents can have the same type of causal powers was irrelevant. Again, arguably the focus on MR in the debate about the mind arises because of the commitment to functionalism. But again, realising that MR is irrelevant to securing emergent materialism for other areas may help to shift the focus of defences of emergent materialism with respect to the mind away from MR and towards a denial of functionalism.

We have seen that eliminative materialism is clearly false. Water and superconductors have causal powers that their parts lack and so are ontologically distinct from their parts. Because it is possible to explain the nature of water and superconductors in terms of their parts it seems appropriate to say that they are physical. All that is "added" to the basic entities of microphysics is organisation of the parts. Although they are mereologically explicable it nevertheless is necessary to retain theories that refer to these emergent phenomena. What we have seen in these examples are cases of explicable emergence. Perhaps more important than the refutation of radical eliminative materialism is the demonstration of the difference between these examples and the standard positions in philosophy of mind. First of all these examples suggest that a focus on denying the possibility of relation higher and lower-level theories is inappropriate because it is possible to obtain mereological explanations for emergent phenomena. Secondly it seems that the focus on explanatory relevance as a sufficient criterion for entry into our ontology is driven by people's commitment to functionalism about the mind and not by the nature of emergence in general. Finally it seems that MR can, at least in the case of water, be irrelevant to securing emergent materialism. The ways in which many philosophers of mind think about emergent materialism do not seem to match up with what is going on in cases of emergent materialism from other domains.

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