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The Mechanical World

The Metaphysical Commitments of the New
Mechanistic Approach

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Contents

1	Introduction	1
1.1	The New Mechanistic Approach: Core Ideas	2
1.2	Why the Metaphysics of Mechanisms Matters	7
1.3	Consequences for the Philosophy of Mind	9
1.4	Goals and Overview	11
	References	13
2	Theories of Mechanism	17
2.1	Wesley Salmon's Approach, the Ontic View, and the Causal-Constitutive Distinction	18
2.2	Complex System Mechanisms	22
2.3	The Acting Entities Approach	25
2.4	Acting Entities Mechanisms and the Etiological/Constitutive Distinction	30
2.5	Comparing Complex System Mechanisms and Acting Entities Mechanisms	32
2.6	Summary	35
	References	36
3	Types of Mechanisms: Ephemeral, Regular, Functional	39
3.1	Functional Mechanisms	41
3.2	Regular Mechanisms	47
3.3	Reversely Regular Mechanisms	58
3.4	Individuating Mechanism Types	61
3.5	Summary	64
	References	66
4	Entity–Activity Dualism	69
4.1	What Are Entities?	70
4.2	What Are Activities?	72
4.3	Entity–Occurrent Dualism	79
4.4	Activity Causation	81

4.5	Summary	90
	References	92
5	Mechanistic Componenty, Relevance, and Levels	95
5.1	Causal Relevance	95
5.2	Constitutive Relevance	98
5.3	Organization and Levels of Mechanisms	102
5.4	Summary	107
	References	108
6	Mechanistic Phenomena	111
6.1	Mechanisms Do Not Explain Capacities	113
6.2	The Functionalist View of Constitutive Mechanistic Phenomena	114
6.3	The Behaving Entity View of Constitutive Mechanistic Phenomena	120
6.4	Summary	124
	References	125
7	Causation and Constitution	129
7.1	Two Notions of Causation	130
7.2	Constitution: Connecting the Dots	135
7.3	A New Interventionist Approach to Constitutive Relevance	137
7.4	Interlevel Causation and Exclusion Worries	146
7.5	Mechanistic Constitution	149
7.6	Summary	150
	References	151
8	Autonomy, Laws of Nature, and the Mind–Body Problem	155
8.1	Summary: The Metaphysics of Mechanisms	155
8.2	The Autonomy of the Special Sciences	159
8.3	Mechanisms vs. Laws—Is the New Mechanistic Approach Original?	160
8.4	Non-reductive Physicalism	162
	References	163

Chapter 1

Introduction



Thinking about mechanisms gives a better way to think about one's ontic commitments. Thinking about mechanisms offers an interesting and good way to look at the history of science. Thinking about mechanisms provides a descriptively adequate way of talking about science and scientific discovery. Thinking about mechanisms presages new ways to handle some important philosophical concepts and problems. In fact, if one does not think about mechanisms, one cannot understand neurobiology and molecular biology.

Machamer et al. (2000, 23f.)

The notions of mechanism and mechanistic explanation have returned to center stage in contemporary philosophy of science. At the turn of the millennium, Peter Machamer, Lindley Darden, and Carl Craver published a paper ('MDC 2000' for short) on mechanisms and mechanistic explanation in biology that initiated an extensive debate about mechanisms and mechanistic explanations in the philosophy of science more generally—and especially in the philosophy of the life sciences.¹ Many authors subsequently contributed to the development and discussion of the new mechanistic thinking, and the research is still ongoing.

¹In this book I am mainly concerned with mechanisms in the life sciences. 'Life sciences' is an umbrella term subsuming all scientific disciplines that are concerned with phenomena of the living. The list of the life sciences ranges from agriculture to zoology and includes disciplines such as bioethics and cognitive neuroscience. I also sometimes speak of 'biological phenomena' for lack of a better term.

1.1 The New Mechanistic Approach: Core Ideas

The central claim of the so-called *new mechanists*—a label that is commonly used to refer to contemporary philosophers who defend a mechanistic view²—is that scientific explanation consists in describing *mechanisms* that are responsible for the phenomena that are to be explained. Mechanisms, according to the new mechanists, are systems or sequences of causally interacting parts organized such that they produce the phenomenon to be explained. Prominent examples of mechanisms discussed in the literature are the action potential mechanism (Craver 2007a; Bechtel 2008), the mechanism for neurotransmitter release (Machamer et al. 2000; Craver 2007a), the mechanism of long-term memory (Bechtel 2008), the spatial memory mechanism (Craver 2007a), the mechanism for protein synthesis (Bechtel and Abrahamsen 2005), systems to regulate the water level in a toilet tank (Glennan 1996), clocks (Glennan 2002), hearts (Glennan 2002), and many others.

Why are the new mechanists called ‘*new mechanists*’? One reason is that the modern thinkers claim to share core ideas with figures in the history of science and philosophy who thought that mechanisms are central for scientific explanation. Indeed, many new mechanists claim that the roots of their thinking are to be found in the ideas of philosophers and scientists from the seventeenth and eighteenth centuries (Machamer 1998; Machamer et al. 2000; Wright and Bechtel 2007). Prominent defenders of the ‘old’ mechanistic approach are, among others, Descartes, La Mettrie, Galileo, and Boyle. Yet it is not entirely clear what exactly unifies these historical approaches (for an overview see Craver and Darden 2005). Sometimes it is claimed that the machine analogy is central to the old and the new mechanistic thinking (Wright and Bechtel 2007; Bechtel and Richardson 2010), but this view is explicitly rejected by some of the new mechanists (Craver 2007a, 4). A more plausible account of the core agreement between the old and the new mechanists is “the view that many target phenomena and their associated regularities are the functioning of *composite hierarchical systems*” (Wright and Bechtel 2007, 45). A further central assumption that is shared by most of the old and the new mechanists is that the empirical sciences proceed by finding new forces and entities that can compose the mechanisms that are responsible for the various phenomena to be explained (Machamer et al. 2000).

As well as these ‘old’ mechanists, there are authors who might be called ‘old *new mechanists*’: between the time of the old mechanists of the seventeenth and eighteenth century and the new mechanists active since the late 1990s, several authors have pointed out the relevance of mechanisms for the life sciences. In the early 1970s, for example, Marjorie Grene and Stuart Kauffman suggested that scientific explanations involve discovering underlying mechanisms that are responsible for the various phenomena that scientists aim to explain (Kauffman called these explanations

²Note that the use of this label is highly idealizing and glosses over the differences between the various views that have been put forward. I highlight some differences between the most popular new mechanistic views in the course of this book, while ignoring differences that I do not take to be relevant for our present purposes.

“parts explanations”; Kauffman 1971; Grene 1974). Other early mechanistic approaches were developed by Robert Brandon (1984), and Wesley Salmon (1984a).

The works of Wesley Salmon were especially influential on the new mechanistic thinking (Campaner 2013). According to Salmon, “what constitutes adequate explanation depends crucially upon the mechanisms that operate in our world” (Salmon 1984a, 240). He defended what he called an ‘ontic view’ of scientific explanation according to which “[s]cientific explanation [...] consists in exhibiting the phenomena-to-be-explained as occupying their places in the patterns and regularities which structure the world” (Salmon 1984a, 239). He contrasted this ontic view with an epistemic and a modal view of explanation, where the former takes explanations to be arguments, and the latter sees explanation as revealing modal dependencies (Salmon 1984b). Salmon distinguished two kinds of ontic explanation (Salmon 1984a, 269ff.): one in which a phenomenon is explained by the mechanism that consists of the *preceding causes* of the phenomenon, and another where a phenomenon is explained by the mechanism that *underlies* or *constitutes* the phenomenon. The former Salmon called *etiological explanations*; the latter he called *constitutive explanations*. Salmon’s distinctions between the different types of explanation, on the one hand, and between the different types of ontic explanation, on the other, are central to the new mechanistic thinking and will be central to later parts of this book as well.

But why do the new mechanists think that mechanisms are central to the life sciences and the philosophical reflection upon them? How does the new mechanistic thinking differ from other contemporary approaches in the philosophy of science? One central idea underlying the new mechanistic approach is that the classical stance on what scientific explanation consists in is mistaken (Craver 2007a, 39). Classically, scientific explanation was taken to have the form of a sound deductive or inductive argument, where the explanans was considered to be a set of two or more premises from which the explanandum—a sentence stating that the phenomenon occurred (or obtains)—could be inferred (as assumed by, for example, the deductive-nomological model (Hempel and Oppenheim 1948), the inductive statistical model (Hempel 1962), or the unification model (Kitcher 1989)). At least one of these premises had to be a law-statement. This model worked well for examples such as the explanation of the position of planet Mars based on Newton’s laws of motion, the inverse square law of gravity, the masses of the sun and Mars, and the position and velocity of both (Woodward 2017).

Yet the new mechanists reject this view of scientific explanation, on the grounds that it is not generally applicable to scientific disciplines other than physics. Rather, they follow Salmon in stating that a phenomenon is explained “by showing how it is situated in the causal structure of the world” (Craver 2007a, 200). According to the new mechanists, phenomena are situated in the causal structure of the world by being produced by mechanisms that correspond to patterns in that causal structure (Bechtel 2008, 2–3). Furthermore, the new mechanistic approach can be seen as in line with the system tradition (Cummins 1975), which takes explanations to consist in decomposing a system into its parts “and showing how those parts are organized together in such a way as to exhibit the *explanandum phenomenon*” (Craver 2007a, 109).

The collections of the parts of a system, organized such that they exhibit a phenomenon, according to the new mechanists, just are mechanisms. Hence, according to the new mechanists, to explain a phenomenon does not require predicting or deducing it. Rather, it consists in *showing how it is brought about*. Furthermore, according to the new mechanistic approach, the explanatory relation in mechanistic explanation is not grounded in logical deduction/induction but in *causation* (in etiological mechanistic explanation) or *constitution* (in constitutive mechanistic explanation). Causation and constitution are taken to be relations between real things in the world, rather than between sentences in an argument.

The new mechanists do not only attempt to provide an alternative to classical law-based approaches to scientific explanation; rather, they have the even stronger aim of providing a whole new philosophy of science that *replaces the traditional law-talk by mechanism-talk*:

the mechanist's rejection of a law-centered picture of science is a part of their general rejection of the 'Euclidean ideal' (Schaffner 2008) of science, according to which knowledge is arranged in closed deductive axiomatic systems with strict law statements as the axioms. How, they ask, would the philosophy of science look if this formal gestalt, which had already worn quite thin in places, were replaced by a more material, mechanistic, gestalt: one emphasizing the causal structures that scientists much more frequently discuss [...]? (Craver and Kaiser 2013)

This goal is mainly motivated by two ideas: first, it is dubious whether there are any strict laws of nature in the life sciences (Craver 2007a, 66–69; Glennan 2010a, 258; Menzies 2012, 787), and second (even if one accepts a more tolerant notion of a law of nature or law-like generalizations), in the empirical sciences law-talk has “little application” (Craver and Kaiser 2013, 127).

A further motivation driving the new mechanists is that they want to provide a fruitful philosophy for the special sciences that diverges from the physics-centric views of traditional philosophy of science. In particular, the new mechanists are critical of the idea that other scientific disciplines qualify as scientific only insofar as they can be *reduced* to physics. The new mechanists are, thus, not only opposed to the physics-centricity of traditional philosophy of science, but they also defend the *autonomy* of the life sciences. On the new mechanists' account, the various scientific disciplines are unified due to the fact that the scientists of the different areas autonomously investigate and explain different levels of one and the same mechanism (Craver 2007a, Chap. 7; Bechtel 2008, Chap. 4). Investigating these different levels of a mechanism requires different research methods, different vocabularies, and different research questions. The different scientific disciplines are said to provide constraints for possible explanations that are discovered by scientific disciplines working on higher or lower mechanistic levels (Craver 2007a, Chap. 7).

In providing a philosophy of the special sciences, a central aim of the new mechanistic thinking is *descriptive adequacy*, i.e., the aim of developing philosophical theories that fit with the way in which scientists actually work. In the context of the new mechanistic approach, this can be read in two ways. According to what I refer to as the *weak reading* of descriptive adequacy, the demand is that philosophy of science should start by looking at actual empirical science in order to account for

what is actually going on in these sciences. In line with this reading, Craver explains his method as follows:

I do not start with a philosophical view of explanation in mind and then attempt to graft it onto what I find in the discussion sections, review articles, and textbooks of neuroscience. Instead, I develop a view of explanation that does justice to the exemplars of explanation in neuroscience and to the standards by which these explanations are evaluated. (Craver 2007a, 2)

This attitude is also reflected by the fact that many mechanists begin their considerations on mechanisms and mechanistic explanation by quoting recent publications in the respective scientific disciplines where research questions, methods, and results are formulated in terms of mechanisms (Machamer et al. 2000, 2; Craver 2007a, 2f.). Hence, according to the weak reading of descriptive adequacy, philosophers should first look at how certain terms, methods, and so on are used in actual science, and then develop a philosophical theory that accounts for this use.

This procedure involves a danger: one cannot exclude the possibility that at least some scientists in at least some cases use or apply terms, methods, etc. inappropriately. Craver admits that descriptive adequacy cannot be reached by simply rephrasing what scientists say about explanation or by taking any explanation scientists provide at face value:

[o]ne cannot simply read off the norms of explanation in neuroscience from a description of what neuroscientists actually do when they form and evaluate explanations. Neuroscientists sometimes make mistakes. They sometimes disagree about whether a proposed explanation is adequate and even about what it would take to show that it is adequate. Explanatory standards change over time, and it is possible that the standards endorsed now might some day be rejected as inadequate. (Craver 2007a, viii–ix)

Craver points out, however, that there is a variety of uncontroversial cases of accepted and rejected explanations. He argues that there is consensus about, for example,

that action potentials are explained by ionic fluxes, that some forms of neurotransmitter release are explained by calcium concentrations in the axon terminal, and that protein sequences are explained, in part, by DNA sequences. (Craver 2007a, ix)

Craver holds that a philosophical analysis of scientific explanation should account for these clear cases, “unless there is compelling reason to suspect that the judgments of science are wrong” (Craver 2007a, ix). Hence, although according to the weak reading of descriptive adequacy, a philosophical analysis of scientific explanation has to begin with actual science and needs to account for those claims that are commonly accepted by scientists, still the claims of scientists are not taken to be inviolable. Some of these claims might turn out to be false for philosophical reasons. The weak reading of descriptive adequacy can be summarized as follows:

(Weak Descriptive Adequacy) Philosophy of science should start by looking at actual empirical science in order to account for what is actually going on in these sciences. Still, philosophical considerations can sometimes trump considerations coming from the sciences.

According to what I call the *strong reading* of descriptive adequacy, philosophical worries about a certain topic, claim, or question are always outplayed by what scientists think about these topics, claims, or questions. This stance on descriptive adequacy implies that genuine philosophical questions and methods may be neglected or even rejected, and the relevance of, for example, metaphysical considerations, conceptual analysis, thought experiments, and the like, denied. The stronger reading of descriptive adequacy reflects what is sometimes called *methodological naturalism* (Papineau 2016)—the view that only the methods of the natural sciences are valid in acquiring knowledge about the world. For example, Bechtel argues:

the naturalist proposes that we should examine how scientific inquiry is conducted by actual scientists and in doing so avail ourselves of the resources of science. That is, the philosopher of science would focus on securing data about how scientists work and developing theoretical accounts that are tested against that data. Although such an approach cannot independently specify norms for doing science, it can draw upon scientists' own identification of cases that constitute good and bad scientific practice and use these to evaluate theories about how science works, as well as to evaluate work within the sciences that are the objects of study. (Bechtel 2008, 7)

Other new mechanists even seem to hold that the mere fact that scientists are silent with regard to certain philosophical claims shows that these claims are false. Bogen, for example, rejects the relevance of counterfactuals for causation because he assumes that

[n]euroscientists who study the action potential try to discover regularities among *actual* rather than counterfactual sequences of events. I submit that this would not be so if counterfactual regularities were necessary for the truths of the causal claims they develop. (Bogen 2005)

The strong reading of descriptive adequacy can be summarized as follows:

(*Strong Descriptive Adequacy*) Philosophical worries about a certain topic, claim, or question are always outplayed by what scientists think about these topics, claims, or questions. There are no genuine philosophical methods, and metaphysical considerations, conceptual analysis, and thought experiments are irrelevant.

The main difference between the weak and the strong reading of descriptive adequacy can be summarized as follows: while according to the weak reading, philosophy at least sometimes trumps empirical science, defenders of the strong reading reject the idea that philosophical considerations can ever be relevant unless they are explicitly reflected by the sciences, let alone falsify claims made by scientists.

The weak interpretation of descriptive adequacy is highly plausible and accepted by most contemporary philosophers of science. In contrast, however, the strong interpretation of descriptive adequacy is misguided. In particular, answering metaphysical and conceptual questions is crucial for providing a coherent theoretical basis for a descriptively adequate approach to scientific explanation. Any descrip-

tively adequate theory has to be grounded on a coherent fundament in order to avoid internal contradictions, ambiguities, misunderstandings, and fallacies. In the next section, I explain how especially *metaphysical* considerations matter to the new mechanistic approach, and thereby motivate the approach of this book.

1.2 Why the Metaphysics of Mechanisms Matters

There are at least two general reasons why it is important to be clear about the metaphysics of the new mechanistic approach. First, the new mechanistic approach has to be conceptually and metaphysically consistent with regard to its ontological commitments, in order to guarantee a satisfying analysis of key notions such as ‘mechanism,’ ‘phenomenon,’ ‘causation,’ ‘entity,’ ‘activity,’ ‘constitution,’ and the like. Second, as suggested in the opening quotation of this chapter, one might wonder whether the new mechanistic thinking has any consequences for other philosophical questions and problems, such as the mind–body problem, physicalism, and other philosophical debates heavily relying on the notion of a mechanism. Regarding the latter, we might think for example of teleosemantics, and current developments in the philosophy of psychology and psychiatry. According to defenders of teleosemantics, intentionality can be naturalized by explicating the content of mental representations in terms of functions of mechanisms (Millikan 1990). Marcin Milkowski (2013) and Gualtiero Piccinini (2015) develop approaches to computation in terms of mechanisms. Current authors in the philosophy of psychology hold that psychological disorders consist in a malfunctioning of psychological mechanisms (Wakefield 1992). These debates could benefit from the new mechanistic approach in borrowing their notion of a mechanism. As these debates focus on metaphysical claims, the successfulness of this endeavor depends on a clear metaphysical analysis of the new mechanistic approach. I will motivate this idea in more detail in the next section, where I outline potential impacts of the new mechanistic thinking for the mind–body problem. Before that, I want to defend the view that, for internal reasons, the new mechanistic account needs a careful metaphysical analysis.

According to most new mechanists, their theories are not meant to deliver a metaphysical analysis of the sciences (an exception is Glennan (1996, 2010a, b, 2011, 2017)), though this is taken to be merely a matter of philosophical division of labor. Usually, the focus lies on epistemological topics such as explanation and scientific change (Machamer et al. 2000, 23). Still, metaphysical considerations are not regarded as being completely irrelevant. In many respects, the new mechanists just remain agnostic as to what the best metaphysics is to account for their ideas. This implies, though, that metaphysical considerations are taken to be subordinate to epistemic claims. The metaphysics had better fit the epistemic claims, rather than the other way around.

However, even those mechanists who want to remain silent with regard to metaphysical issues make a variety of claims committing them to certain metaphysical claims. For example, most mechanists accept that mechanisms are real things that

exist independently of us (Illari and Williamson 2011). Second, they claim that mechanisms are composed of entities and activities, where activities are supposed to be irreducible to property instantiations, capacities, or the like (Machamer et al. 2000; Illari and Williamson 2013). Third, some authors claim that causation in mechanisms is based on activities, where this is supposed to imply a productive notion of causation—without stating what activities are, and how they can account for the productivity they ascribe to causal relations in mechanisms (Machamer et al. 2000; Machamer 2004; Bogen 2005). Fourth, the mechanists usually claim that mechanisms give rise to ‘levels of nature’ (Craver 2007a, Chap. 5) that are “primarily features of the world rather than features of the units or products of science” (Craver 2007a, 177). Fifth, many mechanists hold that mechanisms are the truth-makers of counterfactuals, and law-like generalizations (Glennan 2010b; Craver and Kaiser 2013). Sixth, they assume that some mechanisms constitute the phenomena they explain, where this is supposed to involve some kind of a part–whole relation (Craver 2007a, b; Harbecke 2010; Couch 2011; Baumgartner and Gebharder 2015; Romero 2015). Constitution, in the context of the mechanistic approach, is taken to be a mind-independent relation holding between things in the world. It remains unclear, though, what constitution in the mechanistic context exactly amounts to.

It is clear from this that the new mechanists (even those refraining from making explicit metaphysical claims) are committed to at least some metaphysical claims. With regard to these claims it is difficult, if not impossible, to hold the strong view on descriptive adequacy as introduced before. Some metaphysical problems simply cannot be solved by merely looking at the sciences. Some mechanists seem to aim at avoiding metaphysical investigations by holding that it is not necessary to specify and evaluate their metaphysical claims. For example, with regard to the central claim that the causal components of mechanisms are activities Machamer holds:

[j]ust as one cannot have, or does not need, a theory of organism per se and *tout court*, equally one does not need a theory of *cause*. The problem of causes is not to find a general and adequate ontological or stipulative definition, but a problem of finding out, in any given case, what are the possible, plausible, and actual causes at work in any given mechanism. This does not preclude saying some quite general things about causes, but I shall not elaborate or argue for this point here. The problem of causes, in our terms, is how to discover the entities and activities that make up the mechanism. (Machamer 2004, 27–28)

Of course, it is commonly accepted in philosophy that some notions cannot be defined in the sense of providing necessary and sufficient conditions for their correct application. Some notions can only be characterized by, for example, explicating a family resemblance between things referred to by the term. But the problem in the present context is not only how to define or characterize activities. Rather, the mechanists claim that one can provide an account of causation in terms of activities (Machamer et al. 2000; Illari and Williamson 2013). Specifying how this should work surely requires a specification of what activities are. But it also requires more than that. In order for the claim that activities are causes to make sense, one has to explicate how this is supposed to be the case, and whether this idea can account for the several demands a satisfying approach to causation faces.

I maintain that a philosophical approach to scientific explanation should be able to account for what is actually going on in the sciences. Ideally, it should start with actual science, and then develop an appropriate philosophical account, and not vice versa. Hence, I want to adopt a weak stance on descriptive adequacy. Despite this, though, a philosophical theory should be able to account for basic demands of conceptual and metaphysical clarity. It should avoid ambiguities and be consistent. In this book I analyze the shortcomings, ambiguities, and inconsistencies within the new mechanistic approach and provide a metaphysical analysis that offers a basis for a coherent conceptual framework.

1.3 Consequences for the Philosophy of Mind

Aside from the fact, already indicated, that the new mechanistic approach is in need of a coherent metaphysical analysis for immanent reasons, it might be fruitful to analyze the metaphysical implications of the new mechanistic approach for a further reason. If the new mechanists are right in claiming that many phenomena in the life sciences are due to underlying mechanisms, where some of these phenomena are mental or cognitive phenomena (such as memory), analyzing the metaphysical commitments of the new mechanistic approach might provide new insights relevant for other philosophical problems, such as the mind–body problem. Indeed, my main motivation for thinking about the metaphysics of mechanisms was the following suspicion: many claims of the new mechanists seem to suggest an *ontologically non-reductive* but *physicalist* picture with regard to the phenomena to be explained, as well as to their relation to the mechanisms that bring them about. So, does the new mechanistic approach provide the resources for a new solution to the mind–body problem? The search for an answer to this question guides and frames my argumentation in this book. Therefore, in order to motivate my approach, I now briefly motivate my suspicion, and explain why the new mechanistic approach might have fruitful consequences for the philosophy of mind.

Someone who holds that the mental is real and irreducible to (and non-identical with) the physical, and at the same time maintains that the world is purely physical in some sense, is called a *non-reductive physicalist* (NRPist). According to NRPists, physicalism is true because, first, they agree with reductive physicalists that the physical realm is causally closed, while the mental realm, and the biological realm, are not. Second, NRPists agree with reductive physicalists that the mental depends on the physical in a stronger sense than dualists assume, and that dualism is therefore wrong. Dualists take the connection between the mental and the physical to carry the modal force of maximally *nomological* necessity; NRPists, in contrast, take the relation between the mental and the physical to hold with *metaphysical* necessity. Unlike reductive physicalists, however, they deny that the mental is identical or reducible to the physical.

Different versions of NRP have been offered. These versions differ with regard to two aspects (Pereboom 2002; Loewer 2007; Shoemaker 2007; K. Bennett 2008;

Baker 2009; Wilson 2011; Kroedel 2015). First, different views of the relation between the mental and the physical are defended. Some NRPists hold that the mental *supervenies* on the physical, others hold that the mental is *realized* by the physical, and still others hold that it is *constituted* by the physical. Second, different NRPists accept different theories of causation. Roughly, the different versions of NRP can be divided into those that invoke a production, and those that defend a difference-making theory (see Chap. 7 of this book).

The first aspect is supposed to justify the idea that the mental is non-identical and irreducible to the physical but still physical enough to remain physicalistic. Most NRPists agree that whatever the relation between the mental and the physical is, it must hold in a stronger way than given by nomological necessity. The reason is that in order for mental causation to be real in the NRPists' picture, it has to turn out true that if a putative mental cause does not occur, this implies that its physical base does not occur either, and hence the effect does not occur. Only if this is guaranteed, the counterfactual 'if the mental cause had not occurred, the effect would not have occurred' turns out true (Loewer 2007; Kroedel 2008).

The reductionists' claim that all mental properties are identical to physical properties is usually rejected on the basis of the multiple realizability argument. Since one and the same mental property can be realized/constituted by various physical properties of different types, the mental property cannot be identical to any physical property (for a more detailed presentation of this argument and further arguments in favor of NRP, see Loewer 2007).

The second aspect is supposed to justify how the mental can plausibly be causally efficacious given that the physical realm is causally closed. Many NRPists hold that one can make sense of mental causation if causation is taken to be *difference-making* (e.g., Loewer 2007; Kroedel 2008). It is argued, for example, that on the basis of a Lewisian counterfactual approach to causation, mental causation can be sensibly spelled out (remember the counterfactual stated above). Others assume that even if one takes causation to consist in something stronger, such as transfer of energy or the like (so called *production theories*), the NRPist can make sense of mental causation (K. Bennett 2008).

My suspicion that the new mechanistic approach implies a non-reductive physicalist view with regard to the mind–body problem stems from the fact that the new mechanists make various claims which seem to be similar to those of the NRPists. First, the new mechanistic approach is mainly concerned with neurobiology, neuropsychology, biology, and related disciplines. They talk about explanations of spatial memory, object recognition, etc., which are all mental phenomena (at least in the sense that they involve intentionality). The new mechanists, thus, seem to be talking about things that fall into the scope of the mind–body problem. Second, the new mechanists reject reductionism—at least epistemic versions of reductionism such as Nagelian reduction.³ Unfortunately, they usually remain silent with regard to

³Nagelian reduction is the view that higher-level theories (e.g., biological theories) are reduced to lower-level theories (e.g., physical theories) by deducing the laws of the former from laws of the latter (Nagel 1961).

ontological approaches to reduction. Still, their general motivation, namely rejecting the focus on physics and defending the autonomy of the special sciences, certainly fits well with a rejection of reductive physicalism with regard to higher-level phenomena. Third, the new mechanists make positive claims about the relation between the mental/higher-level phenomena and the physical/lower-level phenomena. The new mechanists assume that cognitive/biological phenomena are *constituted* by mechanisms. It remains to be specified what mechanistic constitution exactly is and whether or not it implies identity. Fourth, although the new mechanists (Craver 2007a; Craver and Bechtel 2007; Bechtel 2008) reject the idea that top-down causation (and, hence, maybe also mental causation) is possible, they hold that the different levels are *mutually manipulable*. That is, they hold that one can manipulate the behavior of the components of a mechanism by manipulating the phenomenon, and vice versa. I will show in Chap. 7 that the new mechanistic picture is not only compatible with interlevel causation but that the acceptance of interlevel causation also helps to solve problems afflicting the idea of mutual manipulability.

In order to evaluate whether the new mechanistic approach indeed suggests a view of the mental and the physical in line with NRP, and whether the former might even be able to provide new arguments for NRP, we first need to become clear about the metaphysics of mechanisms. This will be the goal of this book. I will not provide an answer to whether a mechanistic version of NRP is convincing, or whether it is implied by the new mechanistic approach. Rather, this book provides the grounds for starting to think about these questions.

1.4 Goals and Overview

The aim of this book is to develop a metaphysical account of mechanisms. So far, the new mechanistic literature has mainly focused on epistemic issues such as scientific explanation, scientific discovery, and causal modelling (one important exception is Stuart Glennan's work, especially his 2017 book—I will discuss his earlier views and contrast them with mine as necessary⁴). This book takes a difference stance: I will investigate in which sense mechanisms are things in the world; what our ontology has to look like in order for mechanisms to exist, and its implications for causation, levels, and part-whole relations; and how metaphysics and scientific explanation relate to each other. I will discuss whether the metaphysics of mechanisms is reductionist, and whether it leaves room for the causal efficacy of higher-level phenomena. Finally, I hope to provide a starting point for new projects on

⁴As Glennan's book was published when my book was in the middle of the review process with Springer, I was not able to do justice to Glennan's novel contributions and the modifications he has made to his earlier views. When discussing Glennan's account in this book, I am mainly concerned with his earlier views where this might not account for his views as developed in his 2017 book.

issues in the philosophy of mind, such as non-reductive physicalism as a solution to the mind–body problem.

This book proceeds as follows: in Chap. 2, ‘Theories of Mechanism,’ I introduce three broad categories of approaches to mechanisms. I argue that the currently most prominent approaches to mechanisms can be divided into what I call *Acting Entities Approaches* (AEA) and *Complex System Approaches* (CSA). As I show, these two kinds of approaches have substantially different metaphysical implications. I argue that AEA fare better with regard to descriptive adequacy, and thus provide the better metaphysical framework for thinking about the metaphysics of the life sciences.

In Chap. 3, ‘Types of Mechanisms: Ephemeral, Regular, Functional,’ I introduce a taxonomy of different kinds of mechanisms. In order for the concept of a mechanism to be descriptively adequate with regard to scientific practice it has to go beyond the minimal characterization of the AEA presented in Chap. 2. I argue that there are (at least) three different types of mechanisms inherent in scientific talk: functional mechanisms, regular mechanisms, and reversely regular mechanisms. I show how these three notions together can make sense of mechanistic type-level explanation, function ascriptions and talk about mechanism failures.

In Chap. 4, ‘Entity–Activity Dualism,’ I investigate the nature of the components of mechanisms in the context of the AEA-analysis of mechanisms. I discuss what entities are and which fallacies have to be avoided when individuating them. I provide an account of activities that makes clear how activities differ from entities and from other types of occurrents (such as processes or events). On the basis of this, I argue for a metaphysics that fundamentally consists of what I will call *entity-involving occurrents*. Most importantly, I introduce a new account of causation, *activity causation*, based on the notion of an activity and that of an entity-involving occurrent.

In Chap. 5, ‘Mechanistic Componentcy, Relevance, and Levels,’ I address the question of what distinguishes those entities and activities that are components of a particular mechanism from those that are not. According to Craver’s prominent theory, entities and activities are components of a mechanism for a given phenomenon only if they are causally or constitutively relevant for the phenomenon. I present this view in more detail and introduce the interventionist approach to causal and constitutive relevance. As I will show, the latter in particular turns out to be problematic, and I set out a way to solve this issue which I then elaborate on in Chap. 7. Finally, I discuss the common assumption that entities and activities have to be organized in specific ways in order to form a mechanism. Most importantly, they come in a hierarchical organization. Starting from Craver’s notion of levels of mechanisms, I introduce a new account of levels of mechanisms that makes sense of the idea that things can be at the *same* level.

In Chap. 6, ‘Mechanistic Phenomena,’ I develop an approach to mechanistic phenomena. Phenomena are supposed to be things that are explained, caused, or constituted by mechanisms. I show that there are different views of mechanistic phenomena implicit in the new mechanistic literature. Some philosophers think of phenomena in terms of capacities. I show that this view is incompatible with the AEA-analysis of the metaphysics of mechanisms. Phenomena have to be systems

that manifest behaviors. This latter claim has two interpretations: according to the *functionalist interpretation*, phenomena are either identical with mechanisms, or they are abstract relational properties. Neither of these views is compatible with the metaphysics of mechanisms, and they conflict with anti-reductionism and other broader goals of many new mechanists. I argue that mechanistic phenomena have to be analyzed in terms of what I call the *behaving entity view*. According to this view, phenomena are behaving systems that contain mechanisms, such as moving cars that contain the driving mechanism, or stretching muscles that contain the stretching mechanism.

In Chap. 7, ‘Causation and Constitution,’ I provide an analysis of the different ways in which mechanisms can produce phenomena: by *causing* them and by *constituting* them. I lay bare a tension inherent in my metaphysical analysis: on the one hand, I argue that causation and constitution are metaphysical notions that describe mind-independent aspects of reality. On the other hand, I argue that mechanistic components are causally or constitutively relevant for the phenomenon, where this is spelled out in terms of interventionism, which is not a metaphysical account. The respective accounts have different implications with regard to what counts as a cause or a constituent. I explain how the tension can be resolved. Furthermore, in this chapter I provide a solution to the problem described in Chap. 5: the apparent incompatibility of mechanistic constitution and interventionism. Roughly, I show how the fact that constitution relates EIOs can be used to make sense of mutual manipulability in terms of causation that can straightforwardly be analyzed in terms of interventionism; yet I also show how the metaphysical difference between causation and constitution can be respected. Finally, I analyze the implications of this view with regard to interlevel causation.

In Chap. 8, I provide a summary of my metaphysical analysis of the new mechanistic approach. I discuss the implications of my analysis for antireductionism. Furthermore, I evaluate the ways in which the new mechanistic approach goes beyond classical law-based philosophy of science, and I analyze the consequences of the new mechanistic approach for the metaphysics of mind and brain. The latter can be done only provisionally. Assessing the implications of the new mechanistic approach for the philosophy of mind requires further arguments and considerations, which I will leave for future work.

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