



# Reply to Cartwright, Pemberton, Wieten: “mechanisms, laws and explanation”

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## Abstract

Cartwright et al. in *European Journal for Philosophy of Science*, 10(3) (2020) and the new mechanists agree that regular behaviors described in cp laws are generated by mechanisms. However, there is disagreement with regard to the two questions that Cartwright et al. ask: the *epistemological question* (“What kind of explanation is involved?”) and the *ontological question* (“What is going on in the world?”). Most importantly, Cartwright et al. argue that the explanation involved is a CL-explanation, while the new mechanists insist that mechanistic explanation and CL-explanation are competitors. In this reply, I will highlight some worries regarding Cartwright et al.’s analysis of the relationship between mechanisms and cp laws and I will provide alternative answers to the two questions in line with the new mechanistic approach.

**Keywords** Mechanistic explanation · Covering law explanation · Mechanisms · Nomological machines · Ceteris paribus laws

## 1 Introduction

Cartwright et al. (2020) discuss and provide an answer to the question of how mechanisms explain cp laws or rather regular behaviors that are described in cp laws. By “mechanism” they mean mechanisms as discussed by the so-called *new mechanists* (Bechtel and Abrahamsen 2005; Craver 2007b; Illari and Williamson 2012; Machamer et al. 2000) as well as Cartwright’s own notion of a nomological machine (Cartwright 2005). The new mechanists and Cartwright et al. agree that “cp laws need machines [mechanisms] to generate them” (Pemberton and Cartwright 2014). However, there is disagreement on how mechanisms *explain* cp laws/regular behaviors. This disagreement concerns both of the sub-questions that Cartwright et al. discuss: the

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*epistemological question* (“What kind of explanation is involved?”) and the *ontological question* (“What is going on in the world?”).

The upshot of my critique is that the authors have not provided convincing reasons for accepting that explanations of cp laws/regular behaviors are CL-explanations rather than mechanistic ones in the new mechanists’ sense. This reply proceeds as follows: in Section 2, I will summarize Cartwright et al.’s answers to the epistemological and the ontological question. In Section 3, I will present some worries and alternative answers to both questions in line with the new mechanistic approach. Section 4 concludes.

## 2 The two questions and Cartwright et al.’s answers

With regard to the *epistemological question* (“What kind of explanation is involved?”) Cartwright et al. aim to show that, contrary to the views of the new mechanists, mechanisms explain regular behaviors by being (a subset of) covering-law explanations. In other words, the explanation of a regular behavior (RB) in terms of a mechanism is explanatory (partly) because it shows that the regular behavior *was to be expected*. This claim is in stark contrast with what the new mechanists have claimed: mechanistic explanation is usually depicted as an alternative and competitor to CL-explanation. To make their point, Cartwright et al. summarize and address various objections that have been raised by the new mechanists against the adequacy of CL-explanation (Craver 2007b; Craver and Kaplan 2020):

- a) CL-explanations are unable to deal with causal/etiological explanation;
- b) CL-explanations are only “phenomenological”, i.e., they simply re-describe the phenomenon;
- c) CL-explanations lack explanatory depth;
- d) laws are often unavailable in the biological and special sciences;
- e) CL-explanations require deterministic laws;
- f) CL-explanations confuse prediction and explanation;
- g) there is a general problem of distinguishing laws from accidents and other non-explanatory generalizations;
- h) CL-explanations lack an account of explanatory relevance;
- i) CL-explanations confuse explanation and expectability.

Most of these problems (a, b, c, f, h, i), according to Cartwright et al., are avoided as CL-explanations “don’t do these jobs by virtue of being CL alone” but because they refer to mechanisms. Objections e) and g) are rejected by clarifying the intended notion of a law: “many of the central covering laws used in mechanistic explanations are ‘tendency laws’ (...) that tell what a cause contributes to the effect, not what overall effect actually happens.” Regarding objection d), Cartwright et al. clarify that they accept that laws are often unavailable but that this

has no bearing on whether general laws play a central role in the models biologists construct of how those systems do what they do. (...) [W]hy should we believe that structures that match the model can do what they are supposed to? The answer, we propose, is very often that these effects are just what is to be

expected given the features of the parts in that arrangement and the covering laws in which these features figure. *The effects are just what is to be expected because that is what must happen if all those features act as they should under the general laws that govern them.* (italics in original).

In a nutshell, Cartwright et al. argue that explanations of regular behaviors are mechanistic because they refer to mechanisms (parts, their features, their arrangements) and they are CL-explanations, because they are explanatory in virtue of showing that the regular behavior was to be expected given the mechanism and the laws of nature. Mechanistic explanations of cp laws, so they argue, belong to a special kind of CL-explanation – they are CL-explanations that mention mechanisms.

As an answer the *ontological question* (“What is going on in the world?”), Cartwright et al. introduce an account of “giving rise to” that is supposed to specify what is going on in the world when a mechanism generates a regular behavior: A mechanism M composed of parts P with features  $\Upsilon$  in arrangement A gives rise to a regular behavior RB “if, for some  $\Upsilon' \subseteq \Upsilon$  and general principles  $\lambda(\Upsilon')$  governing features in  $\Upsilon'$ , all the principles in  $\lambda(\Upsilon')$  are instantiated in RB’s occurring.” This account is supposed to express that *it is the regular behavior RB what the instantiation of the laws “amounts to”* (formulation adopted from Cartwright et al. (2020)); it is RB that “was to be expected” given the mechanistic parts, their features and arrangement, and the laws of nature.

Similar to the new mechanists, Cartwright et al. highlight the relevance of the arrangement of the parts of the mechanism (what the new mechanists usually call “organization”). In their view, the arrangement of the parts is crucial as different arrangements introduce new features that the parts in isolation do not have and, thus, “new laws are called into play”. Furthermore, the arrangement fixes the temporal order of what happens when, i.e., which law is instantiated when. Thereby, the laws “determine the continuous behavior of the mechanism through time”.

In a nutshell, the answer to the *ontological question* is a version of the answer to the *epistemological question* with an ontic twist: a regular behavior is explained by a mechanism if the regular behavior was to be expected given the mechanism and the laws of nature; the mechanism generates or “gives rise to” the regular behavior because the regular behavior is what happens (what is to be expected) if the mechanism is instantiated given the laws of nature.

### 3 Worries and alternative answers

#### 3.1 Worry 1: CL-explanation a subtype of mechanistic explanation?

My first worry concerns the claim that mechanistic explanation of cp laws is supposed to be a subtype of CL-explanation. Given that most of the objections against CL-explanations are rejected by adding mechanistic detail, one may wonder whether it is not the other way around: CL-explanation is a subset of mechanistic explanation. This view is supported by Cartwright et al.’s statement that

[t]here may be cases in biology and elsewhere where features in a mechanism do not obey the general principles that they do outside it. There may also be cases where singular causings do not fall under wider principles or laws.

Thus, they seem to admit that sometimes mechanistic explanations are explanatory even though they are not CL-explanations. At the same time, given that the objections against CL-explanation can only be avoided if mechanistic detail is added, there do not seem to be good CL-explanations that are not mechanistic. Still, of course, Cartwright et al. may be right that in cases where CL-explanation and mechanistic explanation go together, the explanatory force comes from the CL-part (only or additionally to the mechanistic part). However, the new mechanists would deny that as well: to explain a phenomenon does not require showing that the phenomenon was to be expected; rather explanation consists in showing how a phenomenon is situated in the causal structure of the world, i.e., by describing the mechanism that brings it about (see next worries).

### 3.2 Worry 2: Where do the laws come in?

In principle, there are three spots where laws may enter the mechanistic picture:

- (i) there are laws governing the activities and interactions of the entities that compose the mechanism,
- (ii) there is a law connecting the mechanism and the phenomenon,
- (iii) mechanistic explanations are explanatory because there are laws that render the phenomenon expectable.

Cartwright et al. seem to want to argue for all three claims. Furthermore, they seem to hold that (iii) is true because (i) and (ii) are true. However, many new mechanists would deny all three claims. To see that, I will first summarize those aspects of the new mechanistic account that are most important for present purposes. Then, I will explain why the new mechanists reject claims (i), (ii), and (iii).

First, similar to Cartwright et al., the new mechanists take mechanisms to consist of parts (entities) that have different features and that are organized temporally, spatially, causally, and hierarchically. Additionally, many new mechanists take activities to be a further non-reducible ingredients of mechanisms (Machamer et al. 2000). Second, the new mechanists usually distinguish between at least two types of mechanistic explanation: *etiological* and *constitutive* mechanistic explanation. While in etiological mechanistic explanation, the mechanism *causes* the phenomenon-to-be explained, in constitutive mechanistic explanation, the mechanism and the phenomenon occur in the same space-time region and they are mutually manipulable – the mechanism *underlies* or *constitutes* the phenomenon. Third, different types of phenomena can be distinguished that serve as explananda in etiological and constitutive mechanistic explanation (Krickel 2018a, Chapter 6): behaviors of systems, input-output relations mediated by mechanisms, and downstream effects of mechanisms. Fourth, the new mechanists claim that phenomena are explained by showing how they are situated within the causal structure of the world (Craver 2007b, p. 20). In other words: one explains a behavior of a system by describing the system's parts and how they interact; one explains an input-output relation by describing the mechanism that receives the input

and delivers the output; and one explains a downstream effect by describing the mechanism that precedes the effect. Fifth, in each case, according to the new mechanists, the mechanism is composed of those entities and activities that *make a difference* to the phenomenon; in other words: that are *causally or constitutively relevant* to the phenomenon (Craver 2007b). And it is their being causally or constitutively relevant for the phenomena that makes mechanisms explanatory.

Thus, the new mechanists reject (i) because they argue that activities are more fundamental than laws (Bogen 2008; Glennan 1996; Illari and Williamson 2013; Machamer 2004; Machamer et al. 2000). They reject (ii) because they take the relation between the mechanism and the phenomenon to be causal or constitutive relevance – none of which (necessarily) relies on the notion of a law (Craver 2007b; Glennan 2017; Krickel 2018a). And they reject (iii) because they take mechanisms to be explanatory because they show how a phenomenon is situated within the causal structure of the world (Craver 2007b), rather than due to the phenomenon's expectability.

In their paper, Cartwright et al. do not really discuss the issue of whether activities or laws of nature are more fundamental. Only, in their discussion of Bogen's account they state that

[w]hen we look at his cases, however, it seems as if the opposite is true [of the claim that activities are prior to laws], just as in our discussion of the neuron example. For instance, Bogen concludes his example of the exploration of fermentation in the latter half of the nineteenth century: "Fermentation turned out to be a physico-chemical process" (Bogen 2008, page 121) – that is to say, as we understand him, that the process follows general physical and chemical principles.

This, of course, does not touch the priority issue. Defenders of activities would not deny that there are general principles that describe mechanisms or activities (Craver and Kaiser 2013). However, most mechanists are singularists holding that activities (tokens) are prior to laws (types) (Glennan 2011). I discuss claims (ii) and (iii) in the next two sections.

### 3.3 Worry 3: Constitution & "giving rise to"

Claim (ii) concerns the relation between the mechanism and the phenomenon – what the new mechanists take to consist in *causation* or *constitution*. Cartwright et al. seem to think that the mechanists leave something out:

But even if we accept that the activities of M constitute the causing of Gs by Fs, that would not solve our puzzle. We still need an account of *why*. Generally, when it is true that x constitutes y, there is a reason why it does so. When x constitutes y, that is not a brute, or isolated, fact. There are other facts without which x would not constitute y.

Cartwright et al. seem to think that mechanisms need a reason to constitute phenomena – and this reason is taken to be laws. In other words, they seem to think that there is a question that is left open: *Why* does the mechanism constitute the behavior? I take them

to have in mind something like “What makes it the case that the mechanism constitutes the phenomenon?”. Their answer is: laws of nature.

Now, Cartwright et al. seem to think that the laws that make it the case that a mechanism constitutes a phenomenon are the laws described in (i) (see previous worry), i.e., those that govern the behaviors of the mechanism’s parts. This is problematic already for the reason that the new mechanists reject (i). A further problem is that reducing the relation between the phenomenon (the regular behavior) and the mechanism to the laws that govern the mechanisms parts can make sense only with regard to one type of mechanistic explanandum, i.e., explanations where an input-output relation is explained in terms of the mechanism that connects the input with the output (see previous worry). Indeed, Cartwright et al. mainly focus on this type of explanation. Agreed - in these cases the phenomenon-mechanism relation may be describable in terms of a chain of laws connecting the input to the intermediate steps (the mechanism) to the output.

However, Cartwright et al. do not address cases of constitution in the new mechanists’ sense, i.e., cases in which the mechanism and the phenomenon occur in the same time and place and are mutually manipulable. Examples are the explanation of the action potential and the explanation of muscle contraction (which are both regular behaviors of neurons/muscles). In these cases, what is to be explained is a behavior of a system that may be characterizable in terms of a set of inputs and a set of outputs. However, the explanation in these cases goes beyond explaining how the input causes the output. Rather, the regular behavior is “multifaceted” (Craver 2007b, p. 125) and requires an explanation that accounts for various aspects that happen *between* the inputs and the outputs. For example, for a satisfactory explanation of the action potential “[i]t is necessary to describe its rate of rise, its peak magnitude, its rate of decline, its refractory period, and so on” (Craver 2007b, p. 125). In these cases, the mechanism-phenomenon relation is not reducible to the input-mechanism-output relation. Rather, the behavior-to-be-explained occurs at the very same time and place as the mechanism. The action potential is propagated *while and where* the ion-channels open and close and ions diffuse. The muscle stretches *while and where* the myosin and actin filaments interact.

Another way to formulate this worry is that Cartwright et al. do not distinguish the *horizontal* (causal) dimension from the *vertical* (hierarchical, constitutive) dimension. They only seem to focus on the horizontal dimension when they argue that the activities and interactions of the parts of a mechanism are governed by laws. With regard to the vertical dimensions, it is unclear, whether they assume that there is a further law, or not. However, the new mechanists have particularly stressed the vertical dimension of mechanistic hierarchies (see also Gillett (2013)) and their role in scientific explanation. Thus, Cartwright et al. do not provide an alternative account to the new mechanists’ account of constitution.

There is a still ongoing debate on what exactly mechanistic constitution is supposed to be – and some authors (especially Harbecke (2015)) have argued that it involves laws (or rather, regularities). However, not all mechanists take constitution to be law-based (Baumgartner and Casini 2017; Craver 2007a; Krickel 2018b). This debate has an important connection to (iii): the new mechanists may accept (but need not) that the best account of mechanistic constitution is in terms of laws (regularities). Still, they need not accept the claim that (constitutive) mechanisms are explanatory *because* they

are lawfully connected to their phenomena. This brings me to my next worry about claim (iii).

### 3.4 Worry 4: Where does the explanatory power come from?

Cartwright et al.'s claim that mechanistic explanations of regular behaviors are CL-explanations can be interpreted in two ways:

- a. Mechanistic explanations of *cp* laws *can be translated* into CL-explanations.
- b. Mechanistic explanations of *cp* laws *are explanatory because* they can be translated into CL-explanations.

Cartwright et al. want to argue for b. However, if at all, they only manage to show a. But a is not very interesting. The new mechanists accept that there are laws (or law-like generalizations) even in the special sciences (Craver and Kaiser 2013). And, as shown in the previous section, they may even accept that the relation between a mechanism and a phenomenon is lawful. However, it does not follow that laws are crucial for the explanation of phenomena (Machamer et al. 2000). Neither does it follow that laws are prior to activities or mechanisms. Most mechanists hold that laws of nature can be reduced to mechanisms (they are “mechanically explicable” (Glennan 2005, p. 446)). The new mechanists may even accept that the interactions in mechanisms are governed by laws (as Glennan did in his earlier papers (Glennan 1996)) without being committed to the claim that mechanisms are explanatory because their components' interactions are governed by laws.

Indeed, most if not all mechanistic explanations can in principle be transformed into the CL-format:

- A1 My car contains a mechanism *m* of type *M* composed of parts *P* (a running engine, a pressed gas pedal, turning wheels) with features  $\Upsilon_a$ -  $\Upsilon_m$  in an arrangement *A*.
- A2 *Cp*, if mechanism *M* occurs in a car, the car moves. (or: the parts are governed by *cp* laws due to some of their features and arrangements and these *cp* laws are all instantiated in the car's moving).
- A3 My car moves (or is likely to move).

This shows that if Cartwright et al.'s argument is valid, then not only mechanistic explanations of *cp* laws are CL-explanations. Indeed, nothing in their argument seems to depend on the explanandum being a regular behavior. The new mechanists could in principle accept that all mechanistic explanations can be brought into the form of a CL-explanation. This is not sufficient to show that these mechanistic explanations are explanatory *because* they can be translated into a CL-explanation. Even if one accepts that standing in an explanatory relation *R* implies standing in some other relation *R\** you are not thereby committed to saying that *R\** is an explanatory relation as well. Hence, by accepting that for every mechanistic explanation there is a translation into the form of CL-explanation, they are not thereby committed to saying that the CL part is what makes them explanatory.

### 3.5 Worry 5: Change of explanandum

Mechanistic explanations explain regular behaviors by answering how-questions (or contrastive why-questions of the form described in Craver and Kaplan (2020) and Kohár and Krickel (forthcoming)). How do muscles contract (cp)? How does a neuron release neurotransmitters (cp)? How is the action potential propagated (cp)? How do coke machines release coke bottles when a coin is inserted (cp)? How do cars move? A good answer (explanation) will describe the mechanism, i.e., the entities and activities and their organization that are responsible (causally/constitutively relevant) for the phenomenon. Now, as stated above, Cartwright et al. think that mechanistic explanations are incomplete as they leave out “why (...) the joint activities of the parts of the mechanism (...) constitute this behavior”. The problem is that even if this was a valid question, it comes along with a change of the explanandum. The question is no longer “How does X work?” but rather “Why does the occurrence of the mechanism lead to the occurrence of X?” The new mechanists could in principle accept that the answer to the latter question is “Because there are laws that are instantiated when the mechanism occurs” (Krickel (2018a, Chapter 7) makes a suggestion in that direction) – however, they need not accept that this is part of the answer to the first question.

## 4 Conclusion

Cartwright et al. do not provide convincing reasons for accepting that explanations of cp laws/regular behaviors in terms of mechanisms are CL-explanations rather than mechanistic explanations in the sense of the new mechanists. According to the mechanists, explananda such as “How does the regular behavior RB arise?” are explained by describing the underlying mechanism, i.e., the entities and activities and their organization. In this response I have argued that the new mechanists could in principle accept that constitution needs laws (which they usually do not accept), and that the interactions between mechanistic components are governed by laws (which they usually do not) but that it does not follow that laws or expectability adds any explanatory power to a mechanistic explanation. Thus, mechanistic explanations (of RB) are not subtypes of CL-explanations. If at all, some CL-explanations are subtypes of mechanistic explanations – they are explanatory because they describe mechanisms.

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## References

- Baumgartner, M., & Casini, L. (2017). An abductive theory of constitution. *Philosophy of Science*, 84(2), 214–233. <https://doi.org/10.1086/690716>.
- Bechtel, W., & Abrahamsen, A. (2005). Explanation: A mechanist alternative. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, 36(2), 421–441. <https://doi.org/10.1016/j.shpsc.2005.03.010>.
- Bogen, J. (2008). Causally productive activities. *Studies in History and Philosophy of Science Part A*, 39(1), 112–123. <https://doi.org/10.1016/j.shpsa.2007.11.009>.
- Cartwright, N. (2005). Where do laws of nature come from? *Dialectica*, 51(1), 65–78. <https://doi.org/10.1111/j.1746-8361.1997.tb00021.x>.
- Cartwright, N., Pemberton, J., & Wieten, S. (2020). Mechanisms, laws and explanation. *European Journal for Philosophy of Science*, 10(3). <https://doi.org/10.1007/s13194-020-00284-y>.
- Craver, C. F. (2007a). Constitutive explanatory relevance. *Journal of Philosophical Research*, 32(section II), 1–20. [https://doi.org/10.5840/jpr\\_2007\\_4](https://doi.org/10.5840/jpr_2007_4).
- Craver, C. F. (2007b). *Explaining the brain: Mechanisms and the mosaic Unity of neuroscience*. Oxford: Oxford University Press.
- Craver, C. F., & Kaiser, M. I. (2013). Mechanism and Laws: Clarifying the debate. *Mechanism and Causality in Biology and Medicine*, 2011, 125–145. <https://doi.org/10.1007/978-94-007-2454-9>.
- Craver, C. F., & Kaplan, D. M. (2020). Are more details better? On the norms of completeness for mechanistic explanations. *The British Journal for the Philosophy of Science*, 71(1), 287–319. <https://doi.org/10.1093/bjps/axy015>.
- Gillett, C. (2013). Constitution, and multiple constitution, in the sciences: Using the neuron to construct a starting framework. *Minds and Machines*, 23(3), 309–337. <https://doi.org/10.1007/s11023-013-9311-9>.
- Glennan, S. (1996). Mechanisms and the nature of causation. *Erkenntnis*, 44(1), 49–71. <https://doi.org/10.1007/BF00172853>.
- Glennan, S. (2005). Modeling mechanisms. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, 36(2 SPEC. ISS.), 443–464. <https://doi.org/10.1016/j.shpsc.2005.03.011>.
- Glennan, S. (2011). Singular and general causal relations: A mechanist perspective. *Causality in the Sciences*, 789–817. <https://doi.org/10.1093/acprof:oso/9780199574131.003.0037>.
- Glennan, S. (2017). *The new mechanical philosophy*. Oxford: Oxford University Press.
- Harbecke, J. (2015). Regularity constitution and the location of mechanistic levels. *Foundations of Science*, 20(3), 323–338. <https://doi.org/10.1007/s10699-014-9371-1>.
- Illari, P. M., & Williamson, J. (2012). What is a mechanism? Thinking about mechanisms across the sciences. *European Journal for Philosophy of Science*, 2(1), 119–135. <https://doi.org/10.1007/s13194-011-0038-2>.
- Illari, P. M., & Williamson, J. (2013). In defence of activities. *Journal for General Philosophy of Science*, 44(1), 69–83. <https://doi.org/10.1007/s10838-013-9217-5>.
- Kohár, M., & Krickel, B. (forthcoming). Contrast and compare: How to choose the relevant details for a mechanistic explanation. In C. Fabrizio & V. Marco (Eds.), *Neural Mechanisms - New Challenges in the Philosophy of Neuroscience*. Cham: Springer.
- Krickel, B. (2018a). *The Mechanical World*. Cham: Springer. <https://doi.org/10.1007/978-3-030-03629-4>.
- Krickel, B. (2018b). Saving the mutual manipulability account of constitutive relevance. *Studies in History and Philosophy of Science Part A*, 68, 58–67. <https://doi.org/10.1016/j.shpsa.2018.01.003>.
- Machamer, P. (2004). Activities and causation: The metaphysics and epistemology of mechanisms. *International Studies in the Philosophy of Science*, 18(1), 27–39. <https://doi.org/10.1080/02698590412331289242>.
- Machamer, P., Darden, L., & Craver, C. F. (2000). Thinking about mechanisms. *Philosophy of Science*, 67(1), 1–25.
- Pemberton, J., & Cartwright, N. (2014). Ceteris paribus Laws need machines to generate them. *Erkenntnis*, 79, 1745–1758. <https://doi.org/10.1007/s10670-014-9639-4>.