Mechanisms, Laws, and Regularities*

Holly K. Andersen[†‡]

Leuridan argued that mechanisms cannot provide a genuine alternative to laws of nature as a model of explanation in the sciences, and he advocates Mitchell's pragmatic account of laws. I first demonstrate that Leuridan gets the order of priority wrong among mechanisms, regularity, and laws, and then make some clarifying remarks about how laws and mechanisms relate to regularities. Mechanisms are not an explanatory alternative to regularities; they are an alternative to laws. The existence of stable regularities in nature is necessary for either model of explanation: regularities are what laws describe and what mechanisms explain.

1. Introduction. In a recent article, Leuridan (2010) has argued that models of mechanisms cannot provide a genuine alternative to laws of nature as a model of explanation in the sciences. He instead advocates Mitchell's (1997, 2000) pragmatic account of laws. The crux of Leuridan's argument concerns the relationship between mechanisms versus laws of nature, on one hand, and patterns of regularity, on the other. While Leuridan makes some interesting points, especially about the connection between Mitchell's pragmatic account of laws and mechanisms, he ultimately gets the order of priority wrong among mechanisms, regularity, and laws. Mechanisms are not an alternative to regularities as a model of explanation; they are an alternative to laws of nature. The existence of stable regularities in nature is necessary for either model of explanation: regularities are what laws describe and what mechanisms explain.

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†To contact the author, please write to: Department of Philosophy, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6, Canada; e-mail: holly_andersen@sfu.ca.

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2. The Relationship between Regularity and Laws versus Mechanisms. Leuridan claims that models of mechanisms in science depend on regularities and, thus, on (a pragmatic account of) laws of nature.[1] He concludes that mechanisms depend on, rather than replace, laws. There are two components to his argument: that mechanisms are ontologically dependent on regularities, but not vice versa, and that mechanisms are epistemologically dependent on laws, but not vice versa. I argue that both of these components are misguided: mechanisms and regularities are equally ontologically basic; and mechanisms may be epistemologically dependent on regularities, but regularities should not be treated as synonymous with laws. I briefly clarify the relationship between regularities and either laws or mechanisms and provide a mechanist response to Leuridan's challenge of stable regularities without known underlying mechanisms.

Leuridan advances four claims to establish that mechanisms depend on stable regularities but that regularities do not depend on mechanisms. The first two are ontologically oriented, the second two epistemologically oriented. His argument is as follows:

1. "Mechanisms are ontologically dependent on stable regularities. There are no mechanisms without both macrolevel and microlevel stable regularities."
2. "There may be stable regularities without any underlying mechanisms."
3. "Models of mechanisms are epistemologically dependent on pragmatic laws. To adequately model a mechanism, one has to incorporate pragmatic laws."
4. "Pragmatic laws are not themselves epistemologically dependent on mechanistic models. They need not always refer to a mechanism underlying the regularity at hand" (Leuridan 2010, 318–19).

First, I want to clarify the way in which his claims 1 and 3 connect: because there are no mechanisms without regularities, mechanisms are ontologically dependent on regularities and epistemologically dependent on laws (Leuridan 2010, 312). Leuridan rightfully points to Mitchell's (1997) pragmatic account of laws as more plausible than accounts that rely on strict universal laws. Laws, in Mitchell's sense, are causal generalizations based on stable regularities in nature, and these generaliza-

1. I follow Leuridan in focusing specifically on the 'new mechanism approach' found in Glennan (1996, 2002), Machamer, Darden, and Craver (2000), Machamer (2004), Bechtel and Abrahamsen (2005), and Bogen (2005). While the views offered by these authors differ in interesting regards, there is sufficient commonality between them (see Tabery 2004) to allow for a comparison of the overall view with alternative accounts of explanation.

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tions allow us to accomplish the same tasks of prediction, explanation, and manipulation for which strict laws were intended. Pragmatic laws are thus closely related to regularities—they are descriptions of regular patterns in a phenomenon, combined with information about the range of circumstances, and manipulations, under which such regularities will remain stable and outside of which they break down (Mitchell 2000). Laws rely on regularities in the sense that the regularities are part of the explanandum of laws. If there were no regular pattern, there simply would be no reason to posit a law, no single coherent phenomenon to which we could attribute the nomologicity that distinguishes laws from accidentally true generalizations.

This leads us to the ontological arguments, claims 1 and 2, offered by Leuridan. He points out that mechanisms depend on regularities, but not vice versa.[2] The first direction is not controversial: regularity figures prominently in most definitions of mechanisms, most notably in Machamer et al. (2000).[3] Phenomena that regularly recur under certain circumstances simply are those which mechanisms are proposed to explain. Mechanism models explain stable regularities because the entities and activities that they describe are regularly linked: the causal chains that comprise mechanisms are regularly triggered given start-up conditions, they regularly lead through the component causal links in the mechanisms, and they regularly produce the termination conditions (Machamer et al. 2000). It is thus misguided to point to the close relationship between mechanisms or mechanism models and regularities as somehow undermining the legitimacy of mechanisms, as Leuridan (2010) does in section 3, "Are Mechanisms an Alternative to Regularities?" Mechanisms are not supposed to be an alternative to regularities; they are an alternative to laws as an explanation of regularities. Laws are not synonymous with regularities, at either the macro- or the microlevel. Regularities are the explananda for which mechanisms are the explanantia.

It could be argued on Leuridan's behalf that mechanisms explain only higher-level regularities since they rely on regularity in the operation of various components. A mechanism could not explain both a higher-level regularity and the lower-level regularities that partially constitute it. But this argument is undermined by the fact that mechanisms are often hierarchically organized (Craver 2007). A mechanism that accounts for a

2. To be clear, his ontological claim concerns mechanisms as the activity-connected chains of entities that we find in the world, not models of mechanisms provided by scientific descriptions of mechanisms.

3. In fact, Bogen (2005) was the first to depart from use of regularity in the definition of a mechanism; he has convinced Machamer (2004) to follow. Regularity need not be conceived of as deterministic; it can be statistical, also (Barros 2008).

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higher-level regularity may include, as part of its constituents, lower-level regularities. But that lower-level regularity would then be accounted for by another mechanism, nested within the first. To take a simplified example, an account for genetic transmission might include a model of mechanisms for gamete production or DNA replication. There will be lower-level regularities in such mechanisms posited to explain those phenomena, which will themselves be fruitfully explained with further mechanisms. The way in which DNA is replicated will include a lower-level mechanism for how single DNA base pairs are replicated, a nested mechanism concerning complex molecular interactions of proteins. Thus, both mechanisms and laws have the capacity to explain regularities at the macrolevel as well as the microlevel.

Leuridan concludes from claims 1 and 2 that mechanisms depend ontologically on regularities. What does it mean to say that mechanisms, which are things in the world, collections of entities and activities organized into coherent chains that recur under appropriate circumstances, depend ontologically on regularities? Mechanisms' ontological character is what grounds their ability to explain regularities in nature when they figure in scientific explanations that involve models of mechanisms. That means mechanisms both incorporate and give rise to regularities. In some sense, this does imply that if no regularities existed, then no mechanisms would either; this seems to be what Leuridan means. But to label this situation one of ontological dependence of mechanisms on regularities is awkward at best. Ontologically speaking, mechanisms and the regularities they give rise to or incorporate in their constituents are on equal footing. Both are equally ontologically basic.

Furthermore, Leuridan's claim cuts both ways: if one holds that mechanisms are part of the 'furniture of the world', then there are no regularities without mechanisms that underlie them (more on this shortly). Laws also 'depend' on stable regularities in much the same way that mechanisms do, if by this one simply means that there would be no laws without regularities. If there were no stable regularities in nature, we would have need of neither mechanisms nor laws. Law-based and mechanism-based accounts both take regularities as integral to the scientific endeavors of prediction, explanation, and manipulation.

In claim 4, Leuridan points to the existence of stable regularities for which we are unable to provide a mechanism and concludes that there can thus be laws without mechanisms. A mechanist response to this actually highlights how mechanism models are in a position to provide better explanations of regularities than laws do. Leuridan is using 'law' to describe generalizations based on stable regularities; his examples include laws of heredity in classical genetics presented by Bateson, Mendel, and Galton (Leuridan 2010, 325–26). Let us grant that the regularities in

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inheritance patterns count as laws and that they provide the means to predict and manipulate patterns of inheritance in future generations (this should not be taken to imply that the classical laws of heredity are still accepted as laws). There may not be anything specifically wrong with calling these laws, if the contrast class is something like accidental generalizations. In this sense, there can be laws without mechanisms. We do not need to have a mechanism already in hand in order to recognize the nonaccidental nature of such regularities.

But this historic picture leaves out the fact that these regularities became the focus of scientific investigation into why they held and how such patterns of inheritance were transmitted. Mechanisms were sought and uncovered as explanations for regularities. That means that a stable regularity is the starting point for a line of scientific inquiry, not its conclusion. Stable regularities offer avenues of research into the mechanisms that sustain them. Unless we think science is already done and wrapped up, there should be a lot of regularities of which we are aware but for which we are unable to, as yet, provide a mechanism. If one follows Leuridan's lead in treating 'law' as the label we give to sufficiently robust regularities, mechanisms then necessarily surpass laws in explanatory capacity, since they start from such regularities and proceed to the underlying entities and activities that give rise to the observed patterns of regularity.

3. A Full Account of Explanation Requires Mechanisms. It is worthwhile to clarify the scope of claims that mechanisms can or cannot replace laws of nature as a model of explanation in the sciences. Leuridan rightly points out that there are fundamental problems with the traditional notion of a law. One such problem is that there are few, if any, candidates for laws if we conceive of them as universal, exceptionless, and necessary. In general, the new mechanism approach does not claim that laws of nature play no role in explanation. Rather, the claim is that while laws of nature potentially describe the kinds of explanations provided by some sciences, such as physics or chemistry, they do not adequately describe the characteristic kinds of explanations provided in biology, neuroscience, psychology, and such 'high level' sciences. As such, it is more accurate to say that new mechanists claim that laws cannot replace mechanisms: we need both. Laws alone are insufficient.

Within sciences like biology and neuroscience, however, there is a fairly straightforward way in which law-based and mechanism accounts of explanation are in direct competition. When generalizations in these sciences are based on stable regularities, they provide us with the means to make predictions, to manipulate systems to bring about specific outcomes, and to explain why things occurred as they did. Law-based accounts and mechanism accounts of explanation both involve a characterization of

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how laws and mechanisms, respectively, are capable of these tasks (Mitchell 1997, 2000; Craver 2007, chap. 4; Leuridan 2010, 325). Both accounts address the range of strength and stability for a given generalization, why it has that range rather than a wider or narrower one, and how we ascertain what that range is.

Leuridan seems to think that the only way we can acknowledge these features of generalizations is by giving them "the honorific label 'law'" (2010, 325) and that "nothing is gained by merely claiming that these regularities are not lawful" (326). This may be true, but it is also a vacuous reason to reject mechanisms. Nothing may be lost by calling a generalization a law; nothing may be gained, either. And in some cases, something may in fact be lost, namely, descriptive adequacy of actual scientific practice. Scientists certainly do, as Leuridan says, work to "discover (statistical) regularities that can be used for prediction, explanation, or interventions" (326). But this does not mean scientists are working to discover laws. Regularities are not identical to laws, and discovering regularities constitutes discovering laws only if one already subscribes to a laws-but-not-mechanisms account of explanation. That is, in fact, the very question at issue; describing scientific investigation of regularities simply as investigation of laws is question begging. Leuridan's claim 3 is based on treating the regularities involved in mechanisms as synonymous with laws. If Leuridan is considering laws and mechanisms as competitors for an account of explanation, then he cannot presume that all regularities are laws. Further, examples abound in the mechanism literature of the abundant use of mechanisms by scientists, including use of the term 'mechanism'. If we are interested in capturing actual scientific practice (326), mechanisms have the edge as the model of explanation.

4. Conclusion. Leuridan identifies a lacuna in the current literature on mechanisms concerning the issue of regularity. Recently, Jim Bogen (2005) has claimed that mechanisms need not be required to act regularly in order to count as mechanisms. This challenge has important consequences for our characterization of mechanisms and causation. How regularly do the start-up and termination conditions need to be connected, in order for the intervening causal chain to count as a mechanism? How frequently does a phenomenon need to occur, in order for it to count as a stable regularity requiring explanation via mechanisms? There are a number of extremely interesting questions to be explored on this topic.

In the end, though, Leuridan puts the cart before the horse. Mechanisms do not replace regularities; they explain them. Likewise, mechanisms do not depend on laws; they supplement them. The relationship between mechanisms and regularities actually tells in the favor of mechanisms as an account of causal explanation in the sciences.

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