Chapters eleven and twelve focus on the development of the concept of the gene and highlight strategies for finding and solving "conceptual problems" in contrast to "empirical problems" such as resolving experimental anomalies. Chapter thirteen discusses the interrelations between Mendelian genetics and other fields, such as chemistry and cytology. Darden identifies strategies that make use of these interrelations to generate new hypotheses, test results in one field against another and, in some cases, resolve anomalies (p. 224). Chapter fourteen summarizes the strategies for theory change exemplified in the development of Mendelian genetics.

In the last substantial chapter, chapter fifteen, Darden discusses these strategies for theory change in relation to more general work in the philosophy of science and artificial intelligence. This provides a broader theoretical background for the strategies she has drawn out of Mendelian genetics and gives reason to think that focusing on those strategies could be useful in understanding theory change in other areas of science as well.

There is little to find fault with in Darden's book. The historical treatment of the development of Mendelian theory is thorough; she looks at both successes and failures, treating them as equally important in identifying strategies for theory change. Perhaps the only drawback is the sketchiness of the treatment of some topics. For example, the discussion of the role of exemplars and diagrams (chapter twelve) left me wondering whether there might be other strategies for theory change tied to the use of exemplars and diagrams in addition to their value in localizing anomalies in the theory.

It is impossible to do justice to the scope and richness of Darden's book in a short review; suffice it to say that her book exemplifies a successful strategy for bringing together the history of science and the philosophy of science. *Bradley E. Wilson, University of Pittsburgh.*

NANCY D. CARTWRIGHT. ***Nature's Capacities and Their Measurement.*** Oxford: Clarendon Press (1989), x + 268 pp., $39.95.

Cartwright's treatise, *Nature's Capacities and Their Measurement*, is a powerful critique of the predominating view of the nature and practice of experimental and predictive science as well as a persuasive case for developing a view of science in the Millean tradition. The predominating view is in the Humean tradition, which sees science as searching for fundamental regularities. Cartwright sees it as searching for capacities, and shows the advantages of her view using case studies drawn primarily from econometrics and modern physics. She provides substantial motivation for further development of the ontological and epistemological bases of this view.

Three lessons constitute Cartwright's case for a Millean view: Causal laws cannot be reduced to regularities, singular causes are required to obtain knowledge about causal regularities, and capacities make singular causal happenings possible. The first two are the most important.

The first is developed in chapter one using econometrics and in chapter two using modern physics. I will discuss econometrics. Cartwright focuses on Simon's characterization of the conditions for which a correlation between two variables is indicative of a causal relation, given certain assumptions. These assumptions do not identify the unique system of functional relations that reveals the underlying causal structure because they do not uniquely establish the relations of dependence and independence between the variables. Econometric theorists suggest that this ambiguity may be removed by requiring the error terms to be uncorrelated. These terms include other explanatory factors, ones that either cannot be easily measured or for which no statistical data exists. If the requirement is satisfied, the missing factors are not significant and the model reveals the crucial elements of the causal structure.

Cartwright rejects this explanation. Error terms correspond to indefinite factors; so, there are insufficient grounds for inferring the true causal structure. If some but not all of them are made definite, a similar ambiguity arises. This leads her to make an interesting and important contribution. She shows that the correct causal structure can be derived if background information concerning the error terms shows that her open back path condition is satisfied. Causal background information is necessary to use this condition. Thus, the causal structure is "bootstrapped" from the statistical data, not reduced to it.

Cartwright indicates how background information can serve this role using Mackie's example involving the Manchester factory hooters. This information includes the belief that the timekeeper's activation of the hooters at midday cannot independently cause Londoners to stop working at five. This belief is reasonable. However, the bootstrap thesis is not entirely convincing; there is no explanation as to how this belief was obtained. It seems that the ambiguity problem can be avoided only by supposing that some causal conceptions are obtained from some source other than statistical regularities. What is their epistemic status? The question is not addressed. However, clues may be drawn from the introduction and chapter four. Cartwright eschews foundationalism, so these conceptions are not from direct observations; nor are they hypotheses, since she advocates the bootstrap method, not hypothetico-deductivism. On the positive side, her metaphor of a rich fabric of interrelated, irreducible factors including singular causes, capacities, interactions, and so on (p. 179) suggests a coherence theory. Perhaps, they are presuppositions or conventions of the inherited background information.

The second lesson is crucial for her case against the Humean's. It is put forth in chapter three, the core of *Nature's Capacities*. In chapter two, Cartwright states her correct-connection principle (**CC**): A factor C is a cause of an effect E if and only if E increases the probability of C in populations where all other causally relevant factors are held fixed. The condition seems unworkable, but for some cases all relevant factors can be held fixed, and for others there are side-stepping techniques. In chapter three, she raises Eells and Sober's counterexample against **CC** in which **CC** gives the wrong causal structure because relevant causal factors that occur after the alleged cause are held fixed. They modify **CC** so that none but causal factors occurring at or before C are held fixed. I refer to their principle as **CC†**.

Cartwright claims that **CC†** runs afoul of another type of case first introduced by Hesslow. Hesslow notes that C (taking oral contraceptives at t_1) can lead to T (thrombosis at t_2). But P (pregnancy) can also lead to T, and C prevents P. So, C can decrease the probability of T even though C is a cause of T. However, by **C†**, this decrease would not reveal the actual causal structure due to a failure to hold P, a key causal factor, fixed at t_1. Cartwright argues that **CC†** cannot reveal it either due to an awkward problem of timing: P can occur after t_1 and before t_2. But, it is unclear why holding fixed at t_1 both P and all factors affecting P's occurrence between t_1 and t_2 would not yield the correct causal structure. Perhaps the real problem is not timing, but too many factors to hold fixed. If so, the claim that Hesslow's case undermines **CC†** is dubious.

Cartwright advocates **CC*** (**CC** plus her principle *), and claims that it can deal effectively with Hesslow's case. Principle * entails that any individuals that have been modified by C are to be reassigned to populations according to the value they would have had in the absence of C's influence. The key for her case against the Humean's is that reassignment must involve singular causal processes; the inferences required concern what will happen in individual cases. How **CC*** is to be operational, however, is unclear; Cartwright does not indicate how to go about obtaining the desired information about singular causes. This is troubling. Singular-causal theorists generally advocate some form of foundationalism, which Cartwright rejects.

Cartwright rejects three other strategies for avoiding the need for singular causes. Her criticisms of the second, path analysis, are paramount. She introduces action variables and uses them to formulate **CC2**, a variant of Reichenbach's common-cause principle (**CC1**), that applies when causes act under constraints. **CC2** is used to offer new insights about Bohm's version of the Einstein-Podolsky-Rosen experiment (**EPR-B**) to show the failings of path analysis. Path analysis falters, she claims, when probabilistic causes act under constaints.

The merits of **CC2** and the alleged failings of path analysis do not fully emerge until chapter six where **EPR-B** is discussed in detail. The upshot is that when the compound system is emitted by the source, a common cause operates under a constraint so as to produce a later effect on each component when one of them is measured. The measured component does not influence its mate at the time of the measurement. There is no action across a spatial gap and no direct action. When a common cause acts under a constraint, there is a new type of causal influence, an action across a temporal gap (**ATG**). The gap is the interval between the time of emission of the compound when the common cause acts and the time of the measurement of one of its components when the action of the cause produces its effect.

CC2 and **ATG** have some plausibility here because the constraints involved in **EPR-B** are conservation constraints; that is, they are a consequence of a conservation principle. However, not all quantum correlations can be explained in terms of a common cause that acts under a conservation constraint. In the original version of **EPR**, position-measurement outcomes are correlated; there is no known conservation principle for position. Moreover, there are many other nonconserved quantities that can have correlated measurement outcomes.

In general, quantum correlations may be explained by common causes that act under constraints only if some constraints are not conservation constraints. This seriously deflates both **CC2** and **ATG**. It is difficult to see how causes acting under constraints can serve any explanatory role unless they have some physical and theoretical basis, such as a conservation or a minimization principle. At least the direct influence model is based on a physical process that can be theoretically characterized: wave-packet reduction. It is hypothetical and controversial. Nevertheless, it renders the direct influence model substantially less objectionable than **ATG**.

Nature's Capacities is somewhat daunting for several reasons. Its technicalities are frustrating. Cartwright shifts from one of several alternative formalisms (linear functions of random variables, Boolean logic, the probability calculus, and variants of these involving action variables) to another. She frequently uses linear modeling, which is not familiar to most philosophers of science; it is necessary to take time to learn the basics (involving elementary statistics) to feel moderately comfortable with her uses of it. She also uses examples from quantum mechanics, which have a significant aspect of mystery to them for many readers. But once some of these obstacles are surmounted, one finds that the issues addressed are weighty and her discussions of them rousing. *Frederick M. Kronz, The University of Texas at Austin.*