BOOK REVIEWS

Nancy Cartwright, ***The Dappled World: A Study of the Boundaries of Science.*** Cambridge: Cambridge University Press (1999), ix + 255 pp. $54.95 (cloth), 19.95 (paper).

The Dappled World is Nancy Cartwright's latest and, to my mind, best exposition of an approach to the philosophy of science she has been developing for two decades. It is even more accessible and more forcefully argued than her widely cited *How the Laws of Physics Lie* (1983) and her more systematic *Nature's Capacities and their Measurement* (1989) — both of which are still in print.

Cartwright's philosophy of science is nicely illustrated by an example she adopts from Otto Neurath (she is co-author of a recent book on Neurath). Imagine dropping a banknote from the top of St. Stephen's Cathedral (in Vienna) and watching it drift down to a spot in the square below. Within the context of classical (non-relativistic, non-quantum) physics, one might suppose that, in principle, the motions of the banknote could be fully accounted for in terms of Newtonian forces. This supposition Cartwright, following Neurath, rejects. She calls adherence to such a supposition (scientific) *fundamentalism*. Fundamentalism, in this context, amounts to generalizing the dominant science of the day to cover literally everything. Cartwright insists that there is no justification for this wild extrapolation from such well-known cases as dropping a cannon ball from the Leaning Tower of Pisa. In the case of the banknote, the effects of air-resistance and random gusts of wind are comparable to those of gravity. There are no specific models in mechanics, or in hydrodynamics, that fit this case. The falling cannon ball, by contrast, is an example of what Cartwright calls a *nomological machine*. For such situations there are specific models which incorporate *laws*, such as Galileo's or Newton's law for falling bodies. Such regularities, she argues, are typically contrived by human intervention, although some, such as the motions of the planets, can be found in nature. Cartwright takes the strong position that one is not justified in positing a lawful regularity in the absence of an explicit model for a nomological machine.

Cartwright earlier rejected realism understood as a thesis about the *truth* of theoretical claims, but she has always retained a realist stance regarding causal relations among theoretical entities. Here she insists that it is *fundamentalism*, not (theory) realism, that is her main target. But there

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is another target as well, namely, the empiricist, Humean conception of causality. For the Humean, causality reduces to regularity among occurrent properties. Cartwright thinks that such a reduction only makes sense in the context of a metaphysics which takes something like sense-data to be the ultimate constituents of (knowable) reality. Modern Humeans, she says, retain the regularity view of causality in spite of having rejected the only sort of metaphysics that might give it plausibility. A proper understanding of causality requires a richer metaphysics, a metaphysics of powers or capacities. For Cartwright, it is capacities which underlie the behavior of nomological machines, which in turn ground empirical regularities.

Cartwright is famous for insisting that laws hold only *ceteris paribus*. A common objection to this position is that on it law claims end up being either false or vacuous. They are false if some relevant factor is left out, which is always the case, or vacuous if all possible relevant factors are included, which can only be done by reducing the law to something of the form: A's are always B's, unless they are not. Here Cartwright notes that this objection rests on the assumption that a *ceteris paribus* law has the form: *Ceteris paribus*, all A's are B's. That, she now insists, is not her view. Rather, the *ceteris paribus* attaches to claims about natures (or capacities). Thus, she would say, it is part of the nature of bodies that they posses the capacity (or power) to attract one another. So, *ceteris paribus*, all bodies attract one another. But also, it is part of the nature of similarly charged bodies that they have the power (or capacity) to repel one another. So, *ceteris paribus*, similarly charged bodies repel one another. What is a poor charged body to do? That, Cartwright insists, depends on the particular circumstances, that is, on the structure of a particular kind of nomological machine. To illustrate her point, she notes that, due to their power to repel one another, free electrons generally move away from each other. She then presents an explicit model of a nomological machine in which two electrons actually move closer together. Though unusual, the circumstances are perfectly compatible with standard, classical, physical theories.

Cartwright is well aware that talk of capacities or natures is still regarded with suspicion even in this post-positivist era. She goes to great lengths to dispel this suspicion. Her efforts are both negative and positive. Among her positive efforts is a charming essay on fables and models. The relationship between powers and models incorporating regularities is, she claims, like the relationship between morals and fables. It is not a relationship between the general and the particular but between the *abstract* and the *concrete*. She considers Lessing's fable illustrating the moral: The weaker are always prey to the stronger. In the fable, a grouse is killed by a martin, the martin by a fox, and the fox by a wolf. The fable is not intended to provide instances supporting a generalization stated in the

moral. Rather, each case is a concrete example of the abstract moral. And each case is different. The way in which a grouse is weaker than a martin is different from the way a fox is weaker than a wolf. Similarly, it is in the nature of gravitational force that masses attract one another and that large masses exert proportionately greater attractive forces. But the way the Earth, for example, exerts a force on a pendulum is different than the way it exerts a force on the moon. Both are concrete manifestations of the abstract nature of gravity for which we have specific models.

She also frequently invokes even more ordinary examples. She may be working all day as a professor. But working is an abstraction. Concretely she is doing things like lecturing to a class, grading papers, advising a graduate student, and attending a departmental meeting. There is no activity that is just working apart from some such concrete realization. She also argues that the relationship between the abstract and the concrete is not the same as that of genus to species, nor of determinable to determinate, nor of supervenience.

On the negative side, she considers a standard empiricist objection to claims about anything other than observable objects and properties. The objection is that, once one exhausts the realm of what is physically observable, there is nothing more to say that has any empirical content. So talk of capacities is empirically empty. Or, even more simply, our experience of the world would be the same whether or not there are capacities. So what could be the empirical justification for introducing such things? Part of Cartwright's response is to raise counter objections to the empiricist's substitute for capacities, universal laws among occurrent properties. Such laws, she argues, are both too plentiful and not plentiful enough. They are too plentiful because of all the universal correlations that are purely accidental. They are not plentiful enough because it is impossible to state true non-accidental generalizations without falling into vacuity. A world with all the associations we in fact observe, she claims, must already be a world with natures behind the regularities.

Cartwright's most telling response to the empiricist argument is to deny the premise on the grounds that it assumes an unjustifiably narrow conception of experience. It is our *experience* of the *practice of science* that provides Cartwright's main reason for positing the existence of powers (or natures or capacities). An appeal to powers, she claims, makes it possible to achieve a far better understanding of the actual practice of science than invoking the empiricists' generalizations regarding occurrent properties. To support this claim she provides us examples of such practice. One of her favorite examples is the Stanford Gravity Probe, a complex instrument consisting of four fused-quartz gyroscopes, electromagnetically suspended in a cryogenic dewar, whose rate of precession is measured by SQUIDS (Superconducting Quantum Interference Devices), and so on. The purpose

of this device is to measure the expected relativistic curvature of space in an Earth orbit by measuring the rate of precession of the gyroscopes. One cannot, she argues, adequately understand the activity of designing and constructing this device in empiricist terms. Rather, one should see the physicists involved as carefully fitting together the various powers of rotational inertia, superconductivity, etc., to construct a one-of-a-kind device that will operate reliably in just the ways required to make the desired measurements.

The Dappled World contains a number of such scientific examples drawing on principles of classical physics, quantum physics, probability theory, and economics. Some more general philosophical readers may be misled by the presence of such examples into thinking that she is concerned primarily with the philosophy of physics or of economics. Nothing could be further from the truth. The issues she raises, and her approach to resolving them, are as fundamental as any for the whole of the philosophy of science, and for philosophy more generally.

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Max Jammer, ***Einstein and Religion: Physics and Theology.*** Princeton: Princeton University Press (1999), 268 pp., $22.95 (cloth).

As the author himself notes, it is astonishing that none of the hundreds of books about Einstein's life and science so far have given an adequate account of "an important facet of his life: his undogmatic and yet profound religiosity and his philosophy of religion" (4). With his book, this strange omission has been rectified in great style. Doing so probably took precisely Max Jammer's combination of expertise and inclinations, for he is a distinguished historian and philosopher of science who knew Einstein, and who, based at Bar-Ilan University in Israel, is personally well informed on religious matters. Even the extensive footnotes will aid future scholars to find hitherto untapped material.

The first of Jammer's three interrelated chapters concern Einstein's attitude toward religion throughout his life cycle. As a child of a nonobservant, assimilated family, he was exposed to divergent religions, in his primary school (Catholic) and his separate instruction, arranged for him to learn the principles of Judaism. Thus for a time, in Einstein's own words, he was led to a "deep religiosity . . . the religious paradise of youth" (19, 28), before a fascination with science abruptly captivated him at about age twelve.

The second chapter analyzes Einstein's ecumenical concepts of the nature of religion and its social expressions, as evidenced in his correspondence and essays. And the final chapter conveys the sometimes quite con-