PHILOSOPHY IN THE LABORATORY*

ALTHOUGH they are from different traditions, Ian Hacking and Patrick Heelan find common ground: they deplore the impoverished representation of experiment in modern philosophy of science. Both writers seek simultaneously to capture the rich historical diversity of experimentation revealed in recent historical studies,[1] and the abstraction needed for philosophical inquiry. And both defend a thesis of phenomenal realism based on the stability of experimental results.

Hacking offers an insightful taxonomy of experimentation which I have reorganized from his twelve items (counting subcategories) into four topics: (1) the focus of experimental inquiry (e.g., choosing between rival theories); (2) the establishment of knowledge prior to experimentation (background knowledge, high theory, instrument knowledge, "topical hypotheses" that bind theory to experiment); (3) experimental materiel; and (4) data and data manipulation (data production, assessment, reduction, analysis, and interpretation). Heelan, too, appreciates the multiplicity of factors contributing to experimentation: "instruments, standard procedures, experimental skills, laboratory traditions, and the social context of the research community." Such taxonomies are needed to understand when and how theory shapes experiment.

Both Hacking and Heelan plea for a naturalized realism grounded in the laboratory: Hacking for an "entity realism," and Heelan for a realism about "scientific phenomena." To get there, each defends the robustness of entities. Building on Edmund Husserl, Heelan advances an intriguing metaphor: just as theoretical physicists search for symmetry groups (e.g., gauge theories) that leave certain theoretical terms unchanged, so, Heelan contends, experimentalists search for phenomena left standing under changes of (1) the state of the observer and (2) the state of the object under investigation. The exploration of these two "practical" symmetry groups and the con-

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[1] See, for example, Peter Achinstein and Owen Hannaway, eds., *Observation, Experiment and Hypothesis in Modern Physical Science* (Cambridge: MIT Press, 1985); Allan Franklin, *The Neglect of Experiment* (New York: Cambridge, 1987); my *How Experiments End* (Chicago: University Press, 1987); David Gooding et al., *The Uses of Experiment* (New York: Cambridge, forthcoming); Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump* (Princeton: University Press, 1985).

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ditions of their implementation make up (as I understand it) "constitution analysis" applied to the experiment/theory relation. That there are such groups—and corresponding invariants—underwrites Heelan's argument for a realism about phenomena.

Hacking defends entity realism against Thomas Kuhn's different–worlds thesis by emphasizing the survivability of entities in a universe of shifting theories. In particular, Hacking stresses the malleability of each of his taxonomic groupings—especially topical hypotheses—as scientists strive to reconcile experiment and theory; but there remains a relative rigidity of entities. According to Hacking, this stability sanctions incommensurable truths about a stable ontology rather than incommensurable ontologies.

Stability, as I see it, must come from more than the convergence of experiment and theory. Logical positivists in the 1920s sought convergence by reducing all science to elementary observation "protocol" sentences. Positivist historians concurred that the proper periodization of science was on two levels: a continuous basis of aggregated observations, and a discontinuous sequence of theories variously organizing the "facts." When the postwar philosophical antipositivists came to prominence, they stood the old scheme on its head: Kuhn (among others) took theory as the ground and observation as the superstructure. Changes of theory dictated changes of observation.

Despite their apparent opposition, both positivists and antipositivists remained committed to the view that the stability of science hinged on whether or not experiment and theory could be reduced to one cohesive bundle. Both take for granted that there is one underlying narrative line (observation for positivists, theory for antipositivists) on which all else rests (epistemically and historically). What is needed is a heterogeneous representation of the periodization of modern science, allowing breaks in theory, instrumentation, and experimentation. The stability of the scientific enterprise rests (in this scheme) not on the total unification of science based on experimental or theoretical reductionism, but on the contingent fact that (1) there are traditions within experiment, theory, and instrumentation; (2) the dislocations within these "subcultures" of physics are not all synchronous; and (3) there are only piece–wise connections between the different strata, not a total convergence or reduction.[2]

[2] On experiment and theory as subcultures of physics, see my *How Experiments End;* on periodization and reduction see my "History, Philosophy, and the Central Metaphor," *Science in Context* (forthcoming, 1988).

The recent discovery of high–temperature superconductivity illustrates a domain of empirical inquiry which proceeded within a tradition of experimentation but against the tenets of accepted theory;[3] the last decade of work on superstrings exemplifies a theoretical field strongly linked to traditions of quantum field theory and general relativity, but many orders of magnitude distant from connection to laboratory observation. Constraints other than the convergence of experiment and theory are at work (e.g., instrumental tests of superconductivity and theoretical constraints based on renormalizability and symmetries). These constraints on theory and instrumentation give rise to a stability and partial autonomy of these strata similar to that of the stratum of experimentation. Paradoxically, then, the stability of science may be better understood from its disunity than from an artificial unity imposed by the total reduction of science to observation, to high theory, or to experimentation.

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[3] On experimental traditions see: my "Bubble Chambers and the Experimental Workplace," in Achinstein and Hannaway; and Galison and Assmus, "Artificial Clouds, Real Particles," in Gooding, ed.