ACKNOWLEDGMENTS

This commentary benefited from discussions with the members of the Prati-ScienS group. We would like to acknowledge our debt to them here, and also thank Karine Chemla for her contribution to this volume and her insightful answers to our inquiries.

9 Scientific Practice and the Scientific Image

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In some remote corner of the universe, poured out and glittering in innumerable solar systems, there once was a star on which clever animals invented knowlégé. That was the haughtiest and most mendacious minute of “world history”—yet only a minute. After nature had drawn a few breaths the star grew cold, and the clever animals had to die. One might invent such a fable and still not have illustrated sufficiently how wretched, how shadowy and flighty, how aimless and arbitrary, the human intellect appears in nature. There have been eternities when it did not exist; and when it is done for again, nothing will have happened.


This passage from Nietzsche’s early manuscripts both draws upon and ironically denigrates our capacities for scientific understanding. The tension underlying Nietzsche’s fable and commentary has been taken up in a different way in an influential essay by Wilfrid Sellars (2007). Sellars framed one of the central issues in 20th-century philosophy as the relation between two influential “images” or conceptions of ourselves and our place in the universe. The “manifest image” understands us as persons, rational, sentient agents accountable to norms: “to think is to be able to measure one’s thoughts by standards of correctness, of relevance, of evidence” (Sellars 2007, p. 374). The “scientific image” is the composite formed from the explanatory theoretical postulations of the sciences: a systematic, scientific representation of nature that explains its manifold appearances. For philosophical naturalists, the scientific image takes priority: as Sellars put it, “in the dimension of describing and explaining the world, science is the measure of all things, of what is that it is, and of what is not that it is not” (1997, p. 83). Critics of naturalism respond that scientific claims are only authoritative for us because they answer to rational norms of understanding and justification. Sellars sought to do justice to the comprehensiveness and apparent autonomy of both images, combining them in what he called a “stereoscopically unified” vision of ourselves in the world.
I am sympathetic to Sellars' broadly naturalistic approach to such a stereoscopic vision of ourselves in the world, but further work is needed to make it defensible. In a forthcoming book, Articulating the World, I argue that a revised conception of both images is needed to reconcile our scientific understanding of ourselves as natural beings with our philosophical sense of ourselves as answerable to conceptual norms. Here I develop an overview of how this larger project requires revision to our understanding of "the scientific image". Although Sellars intended the phrase to apply primarily to how the sciences understand the natural world, it also embodied a conception of scientific understanding. Implicit in his conception of "the scientific image" was a repudiation of the then-predominant empiricist-foundationalist conception of scientific knowledge. In its place, Sellars offered a conception of "[science's sophisticated extension of] empirical knowledge as rational, not because it has a foundation, but because it is a self-correcting enterprise" (1977, p. 79). Yet Sellars' conception of the scientific image is still a conception of a body of scientific knowledge. We need to replace that conception in turn with one that emphasizes understanding scientific practice.

How would an emphasis upon science as practice revise the scientific image, in its dual sense of a scientific understanding of the world and a conception of scientific understanding? Many advocates of a "practice turn" in philosophy deny that the sciences produce, or even aim to produce, a single, unified conception of the world. Scientific understanding is supposedly a disunified patchwork that need not even aspire to the ideal of the "Perfect Model Model" (Teller, 2001) implicit in Sellars' vision. Scientific disunity has itself been conceived in various ways: as theoretical understanding embodied in diverse models whose cross-classifications are useful and informative for some purposes and not others (Teller, 2001; Giere, 1988, 2006a); in laws of limited scope whose gerrymandered domains are circumscribed by where they admit of even approximately accurate models (Cartwright, 1999); in the mutual adjustment of highly specialized theory and instrumentation such that "the several systematic and topical theories that we retain ... are true to different phenomena and different data domains" (Hacking, 1992b, p. 37); in the collective inferential stability of different sets of laws across different ranges of counterfactual perturbation, corresponding to different scientific domains governed by different interests (Lange, 2000); or as a recognition of the metaphysical "disorder" of things (Dupre, 1993), a disorder perhaps most radically expressed in the speculative vision of scientific understanding as like "a Borgesian library, each book of which is as brief as possible, yet each book of which is inconsistent with every other [such that] for every book, there is some huma

Advocates of the disunity of science are onto something important, but it is not sufficient to see the import of the practice turn as primarily a rejection of the unity of science. For one thing, Sellars himself was attentive to the plurality of scientific theories, disciplines, and domains, and thought it could be accommodated within his account of the scientific image, understood as an idealization drawn from a more complex and messy practice:

Diversity of this kind is compatible with intrinsic "identity" of the theoretical entities themselves, that is, with saying [for example] that biochemical compounds are "identical" with patterns of sub-atomic particles. For to make this "identification" is simply to say that two theoretical structures, each with its own connection to the perceptible world, could be replaced by one theoretical framework connected at two levels of complexity via different instruments and procedures to the world as perceived. (2007, p. 389)

Yet I think there is a more fundamental issue underlying Sellars' disagreements with the advocates of scientific disunity. Sellars shares with the disunifiers a conception of scientific understanding as representing the world, whether or not these various representations can be unified into a single, idealized, systematic "image". Scientific understanding is supposedly embodied in scientific knowledge. Whether that knowledge primarily takes propositional form, or is realized to a substantial extent through mathematical, material, visual, or computational models, scientific understanding is mediated in whole or part by a representational simulacrum of the world it seeks to understand.1 This representationalist vision of scientific understanding has been especially influential among naturalists in the philosophy of mind and language, who have often taken mental or linguistic representation as the key to accommodating scientific understanding itself within a scientific conception of the world (Dennett, 1987; Dretske, 1981; Fodor, 1979; Millikan, 1984). If scientific understanding is representational, then a naturalistic account of mental or linguistic representation might suffice at a single stroke to incorporate scientific understanding of the world within the world so understood. I think this aspiration is misplaced, and if so, we need to look elsewhere to grasp what a scientific understanding of the world could amount to. A central part of the difficulty is the aspiration to identify the shape or form of scientific knowledge as a whole, whether conceived as a systematic, unified "image" or as a less systematically integrated set of partial representations for different purposes. Indeed, I shall argue, a more adequate account of scientific understanding must do justice both to its disunified practices and achievements, and to the ways in which those diversions nevertheless remain mutually accountable within an interconnected discursive practice.

Sellars himself offers a key formulation that points toward the possibility of a naturalistic alternative to representationalist conceptions of scientific understanding. In a justly famous passage from "Empiricism and the Philosophy of Mind", he argued that "in characterizing an episode or a state as
that of knowing, we are not giving an empirical description of that episode or state; we are placing it in the logical space of reasons, of justifying and being able to justify what one says” (Sellars, 1997, p. 76). Representationalist conceptions have identified scientific understanding with some specific position or set of positions within the space of reasons, that is, as a body of knowledge that represents the world as aspects of it in particular ways. I respond that scientific understanding should instead be conceived as the constitution and reconfiguration of the entire space. The sciences change the terms and inferential relations through which we understand the world, which aspects of the world are salient and significant within that understanding, and how those aspects of the world matter to that overall understanding. Scientific research also brings aspects of the world into the space of reasons by articulating them conceptually, so as to allow them to be discussed, understood, recognized, and responded to in ways that are open to reasoned assessment.

The sciences thus mark a continuation and expansion of a characteristic feature of human life more generally. We human beings are organisms whose way of life configures our surroundings as an environment with which we interact perceptually and practically. Yet our environment is the outcome of both intensive and extensive niche construction (Odling-Smee, Laland, & Feldman, 2003), with linguistic performances as salient features of our inherited environment.² Language functions within a broader pattern of material and social interaction, in which our way of life and the environment it discloses are themselves at issue for us. Conceptually contentious engagement with the world only emerges in this context. Specifically linguistic performances thus play a central role in conceptual articulation, but only as integral components of a larger field of practical involvement.

This approach emphasizes that the sciences only emerge historically within an already well-established pattern of discursive and material niche construction, and need to be understood as extensions of that pattern. Scientific inquiry takes place within the pervasive setting of human life as a conceptually articulated understanding and engagement with the world. It is a commonplace to think of the sciences’ contribution as the attainment and growth of knowledge, which also discards false belief and undercuts the acceptance of mysterious or incomprehensible powers. That commonplace lies behind a Sellarsian conception of the scientific image, and suitably qualified, that commonplace thought is surely correct. Yet a more fundamental achievement underlies the acquisition and refinement of knowledge through scientific inquiry. Scientific knowledge is possible only because of ongoing practical work within the sciences and a broadly scientific culture,³ which enables relevant aspects of the world to show up at all within the space of conceptually articulated understanding. Through scientific inquiry, human beings are able to talk about, act upon, recognize, and reason about aspects of the world that had previously been inaccessible. Similarly, the sciences show how to understand interrelations among aspects of the world that were previously disconnected. Of course, these efforts also close off or render dubious other conceptual relations and even whole domains that once seemed accessible and intelligible. The critical dimension of science is not merely a matter of falsifying claims, but also of reconfiguring the conceptual space within which they are intelligible.

Being able to say what others cannot, and to talk about things not within their ken, is not just a matter of learning new words; it requires being able to tell what you are talking about with those words.⁴ As John Haugeland once noted,

Telling [in the sense of telling what something is, telling things apart, or telling the differences between them] can often be expressed in words, but is not in itself essentially verbal. . . . People can tell things for which they have no words, including things that are hard to tell. (1998, p. 313)

The sciences allow us to talk about an extraordinary range of things, by enabling us to tell about them, and tell them apart. To pick a small sample of exemplary cases, people can now tell and talk about mitochondria, the pre-Cambrian Era, subatomic particles, tectonic plates, retroviruses, spiral galaxies, and chemical kinetics. One need not go back very far historically to find not error, but silence, on these and so many more scientific topics.

Despite widespread assumptions to the contrary, the conceptual articulation that enables such discursive achievements is not merely intralinguistic. The normative space of conceptually articulated understanding is not limited to a logical space of intralinguistic inferences that only engages the world at occasional observational and practical interfaces.⁵ Practical skills, perceptual discriminations, material transformations of the world, and a socially articulated way of life (including scientific life) integrally contribute to opening and sustaining possibilities for conceptual understanding. In this respect, scientific understanding resembles the larger process of discursive niche construction to which it contributes. Yet in many ways, scientific concepts are especially intensively interdependent with practical skills, equipment, and the creation of new material arrangements in specially prepared work sites. Even though scientific concepts and theories aim to provide understanding of the world as we find it, their proximate application is typically to the world as we make it in the specialized setting of laboratories or field practices. The point goes far beyond the commonplace that the sciences conduct experiments to assess the accuracy of their claims. Experimental work in the sciences normally involves constructing, maintaining, and revising whole “experimental systems”, in which simplified, purified, or constructed elements are brought together in regimented settings that enable their interactions to manifest themselves in clear patterns that enable a domain of objects and events to be articulated conceptually. These experimental systems constitute a kind of “microworld”, within which the relevant concepts acquire exemplary uses and normative governance.⁶ It is
in this respect that the making of laboratories, experimental systems, and conceptually articulated domains of scientific understanding and research go hand in hand. Scientific research thereby introduces a deliberate expansion and re-configuration of the available possibilities for conceptual understanding. It seeks to make salient and comprehensible many aspects of the world that would otherwise be hidden and inaccessible to us perceptually, practically, or discursively. While the inferential relations among concepts and judgments are indispensable to that process of conceptual transformation, the sciences also require more extensive efforts to connect those concepts to newly accessible or salient features of the world.

Understanding conceptual articulation in the sciences thus requires a more inclusive conception of the sciences as social and material practices than has been common in most philosophical reflection upon scientific understanding and scientific concepts. Such an account begins with the recognition that the sciences are first and foremost research enterprises. “Scientists” in the primary sense are those people who are engaged in empirical inquiry, whether as primary investigators, or as active members of a larger research team. Yet the research enterprise, as a distinctive form of niche construction, extends far beyond the scientists whose work constitutes its primary focus. Scientific research depends upon an extensive institutional structure, ranging from disciplinary and other professional associations, journals and other publishers, to the universities, hospitals, institutes, government agencies, or corporations in which research activities are situated. Scientific research has become extraordinarily expensive, and its changing sources of financial and other material support are also integral to the research enterprise, especially where they help shape the priorities and direction of research itself. A significant part of that expense is devoted to material resources. The equipment, materials, research sites, and other physical infrastructure of the sciences have become complex and sophisticated, but also sufficiently widely used to support their own supply networks.

Part of that wider use of scientific material and equipment reflects the extension of scientific concepts, instrumentation, materials, and practices beyond the research laboratory, as scientific understanding has become materially as well as conceptually embedded throughout modern industrial societies. Laboratories and their component apparatus and skills are not solely research facilities. Nor can the research enterprise be limited to its suppliers, consumers, and institutional context. Scientific research is of limited import unless its achievements are disseminated more broadly, and the skills, understanding, and research orientation of its participants are differentially reproduced in succeeding generations. This pedagogical and disseminative role has grown to dwarf the primary research component, such that there are many more science teachers, writers, and administrators than there are scientists. Scientific education is not merely intended to produce more scientists, but also to embed scientific concepts and scientific understanding throughout a broad range of modern society and culture.

Even though the active contributors to research are comparatively few in number and fairly readily identifiable, the research enterprise that sustains them is thoroughly entangled with government, the economy, culture, and a wide range of professions and activities that are not themselves primarily scientific.

I emphasize the expansive scope and pervasive social entanglement of the scientific research enterprise as a reminder of the complexity of scientific understanding. Philosophers of science often seek to compartmentalize and narrow the phenomena we seek to understand, both because of our own parochial disciplinary interests in the sciences as intellectual achievements, and in order to make our subject matter tractable. The result has been a highly idealized, disembodied, and largely retrospective conception of scientific understanding and its conceptual content. Philosophers have typically identified science first and foremost with a systematic “body” of knowledge claims that is nowhere actually assembled and expressed in that form, and that in any case extracted from the diverse and complex institutional and material settings within which those verbal and mathematical formulations are articulated, understood, and deployed. We have largely neglected the factors involved in determining which research questions are important, which ones are actually pursued, and what forms the pursuit takes. We have likewise neglected how the resulting achievements are actually understood, deployed, and implemented. Yet these developments of scientific understanding have substantially transformed the world we live in, and the ways we talk about and understand that world. Such an idealized and disembodied philosophical conception of scientific understanding is especially unsuited for naturalists. At the very least, naturalists who endorse a more traditional conception of the scientific image owe an account of how their idealized image is actually to be discerned among the more diverse, messy and complex practices in which scientific understanding is embedded. Even that might not be enough, however, if we take seriously an account of the evolution of conceptual understanding as a form of niche construction. If scientific understanding is itself a further development of our material and behavioral niche construction, then to abstract away from a more expansive conception of science as a research enterprise would be to give up on a naturalistic account of scientific understanding.

Understanding the sciences as research enterprises also requires a different conception of the temporality of scientific understanding. The predominant philosophical accounts of scientific understanding are retrospective, looking back at the structure and content of what has already been understood and codified as scientific knowledge. That retrospective orientation often persists even in thinking about possible future developments in the sciences. These possibilities are typically addressed in the future perfect tense, by looking forward speculatively to the further development of science, whether or not that speculation is carried all the way to the supposedly regulative ideal of a completed science. Philosophical conceptions of science
still typically look forward to looking back from the vantage point of a scientific knowledge not yet achieved.

This retrospective philosophical orientation is in sharp contrast to the understanding that drives the practice of scientific research. Research workers have a more prospective understanding of their field, as oriented toward outstanding problems and opportunities. While they certainly rely upon what has already been achieved, their understanding of the content and significance of those achievements is transformed by their concern to move beyond it. What were once research topics in their own right are now often regarded not so much as achieved propositional knowledge, but instead as reliable effects and procedures that can be used as tools to explore and articulate new possibilities (Rheinberger, 1997). The concepts employed are understood as open-textured in ways that both permit and encourage further articulation and possible correction of previous patterns of use. Not just which scientific claims to accept, but what those claims say about the world, is always open to further transformation. Empirical inquiry involves the articulation of concepts, including the refined skills, practices and material reconstructions of the world through which those concepts become both meaningful and informative about the world. Above all, the significance of various topics, claims, tools, and issues is organized around their place in the configuration of available and promising research opportunities, rather than their role in the systematic reconstruction of current knowledge.

Yet it is not just an orientation toward outstanding issues and opportunities for research that makes for a divergence between scientific understanding of a research field and philosophical conceptions of the scientific image as an idealized retrospective reconstruction. Even the retrospective assessment of what has already been accomplished in a scientific research field is re-structured by an orientation toward research. Researchers do, after all, engage in retrospective assessments, and those compilations are actually produced in specific forms, ranging from review articles in journals to textbooks and handbooks. Yet none of these summations, either individually or collectively, exemplifies anything like philosophers’ conception of the scientific image. Each compilation is intended for specific audiences, and their content is selected and organized for their prospective significance for the research enterprise. Review articles are oriented toward assessing the significance of recent work in the field for subsequent research. Textbooks focus upon the skills and knowledge likely to be needed by the next generation of scientists. Handbooks and atlases are similarly selective and prospective. Yet one also cannot take the primary journal literature as a distributed repository of the scientific image, since it includes conflicting reports as well as preliminary findings understood as open to, and even oriented toward, subsequent further development and correction. Moreover, in many fields, research develops rapidly enough that researchers’ grasp of the field typically forges well ahead of the published literature. Actual compilations of scientific knowledge are thus always partial and oriented toward what is significant for specific projects, and the notion of an all-purpose or no-specific-purpose compilation may be an oxymoron. Indeed, the suspicion arises that the conception of a unified “scientific image”, a systematic, idealized compilation of scientific knowledge as a whole apart from any specific purposive use of it, is intended to serve the specifically first-philosophical purposes of epistemology and metaphysics. Naturalists ought to be worried about this aspiration.

Perhaps the clearest indication of the divergence between researchers’ understanding and anything like a Sellarsian “scientific image” is provided by the unusual occasions for sustained efforts to identify a scientific consensus on the current state of knowledge. Such efforts have recently been undertaken with extraordinary care and thoroughness across the multidisciplinary domain of climate science, in the reports of the Intergovernmental Panel on Climate Change (IPCC, 1990, 1995, 2001, 2007). The research literature and the opinions of research scientists have been carefully and comprehensively vetted, with a thorough review process aiming to correct errors and accommodate critical assessment of preliminary drafts. Disagreement has been recognized and accommodated by incorporating estimates of degrees of confidence within the reporting of results and predictions. Yet the inherent conservatism of the process of consensus-formation, alongside the cautions provoked by awareness of vigilant critics and skeptics even among the governments responsible for the review process, strongly suggest that most researchers’ own understanding of climate science often diverges from the IPCC conclusions, even when they endorse the process and its outcome as an expression of scientific consensus. The point is not to suggest flaws in the IPCC process or reports, but instead to highlight the possible divergence between scientific understanding and even the most diligent and thorough determination of a “scientific consensus”. Both the idea of a scientific consensus, and that of the “scientific image” as a characterization of scientific understanding, are idealized composites. Yet they may not be the same idealized composite. The issue is whether scientific understanding is adequately expressed as a collective consensus or composite representational “image”, even when its constituent judgments are qualified by estimates of confidence or reliability.

These conceptions of the scientific image as a comprehensive representation of the world, and of the space of reasons as an intra-linguistic domain, nevertheless retain the virtues of familiarity and sophisticated philosophical articulation. Philosophers have developed a rich vocabulary for talking about knowledge and inference in these terms, and a good understanding of how to use that vocabulary to understand the methods and achievements of the sciences. What alternative can I offer to these familiar accounts of the scientific image as an empirically justified, systematic representation of the world? Without a serious alternative conception of scientific understanding, philosophical naturalists will continue to fall back upon the familiar
premption that science aspires to a systematic representation of the world, justified within an intralinguistic space of reasoning.\(^\text{11}\)

In what follows, I sketch an alternative way to think about a scientific conception of the world and the naturalistic philosophical stance that it helps constitute. Familiar accounts of the scientific image, and the space of reasons within which it is expressed and justified, assume that these are relatively self-contained linguistic expressions or activities. I argue instead that conceptual understanding in the sciences involves material, social, and discursive transformations of the human environment, taken together. These transformations amount to extensive forms of what evolutionary biologists call niche construction (Odling-Smee, Laland, & Feldman, 2003). An environmental niche is not something specifiable apart from the way of life of an organism, which in turn cannot be understood except in its specific patterns of interdependence with its environment. A niche is a configuration of the world itself as relevant to an ongoing pattern of activity. Yet organismic activities in turn affect their environment, in ways that bear upon the subsequent development of the organism and its way of life. Such processes become all the more consequential to the extent that an environmental niche is transformed by the organism's own forms of niche construction. The emergence of discursive practice, conceptual normativity, and ultimately scientific understanding within our evolutionary lineage places our own way of life at issue for itself in its continuing reproduction and development.

Thomas Kuhn was widely criticized for claiming that "after discovering oxygen, Lavoisier worked in a different world" (1970, p. 118), but in a quite straightforward sense, even ordinary "normal" scientific research is world-transforming. Scientific practices re-arrange things so that novel aspects of the world show themselves, and familiar features are manifest in new ways and new guises. They develop and pass on new behaviors and skills (including new patterns of talk), which also require changes in prior patterns of talk, perception, and action to accommodate these novel possibilities. These developments thereby introduce new ways of understanding ourselves and living our lives, while reconfiguring or even closing off some previously familiar possibilities. Overall, they reconfigure the world we live in as a normative space, a field of meaningful and significant possibilities for living a life and understanding ourselves and the world.

The sciences thereby conceptually articulate the world itself (and not just our thought or talk about it). We are often inclined to say that the world itself does not change, but only our patterns of talk, thought, and social relations. The world is thereby conceived as already articulated into entities and properties, which may or may not be discernible to us, with nothing we can say or do to change that, except by adding new kinds of human-made artifact. Yet such dismissive claims presume that changes in how we talk, think, and relate to one another and things around us are not themselves changes in the world. They certainly are changes in our practical, perceptual, and socially interactive environment. More important, however, these changes wrought by scientific work also allow the world to show itself in new patterns, with newly discriminable elements, and new significance. These patterns are not themselves intelligible as patterns, except in relation to the correlative forms and norms of pattern-recognition (Haugeland, 1998, ch. 12; Dennett, 1991).

The idea that scientific understanding and other conceptual transformations are also world-transforming has sometimes been dismissed as a kind of fuzzy-minded, unscientific, idealist metaphysics (Scheffler, 1967). How could changes in our thoughts or utterances change the world they describe and not just our descriptions of it? I instead take the world-transforming character of scientific inquiry to be a straightforward commonplace for any naturalistic understanding of ourselves and the world. Naturalists should instead reject that notion that conceptual understanding is merely a matter of thoughts or utterances in isolation. Conceptual content and authority incorporate patterns of material interaction within an environment. Claiming that changes in conceptual understanding do not change the world implicitly presupposes that changes in conceptual content can take place and be recognized intra-linguistically. Changes in language then need not involve changes in the world, because changes in language would be contained within language. If instead we understand language and conceptual understanding as integral to larger patterns of interaction with the world that constitute our environment and our biological way of life, then the notion that the development and ongoing revisions of language are integral to changes in the world should be unsurprising.

Part of a reconception of scientific understanding as niche construction emphasizes its mediation by experimental practice and theoretical modeling. The sciences transform the world around us and the capacities through which we encounter and live in it, and only thereby allow it to be intelligible to us in revealing ways. The result is a conception of scientific practice as an ongoing reconfiguration of our discursively articulated environmental niche. Although I do not explicitly address this point here, the first part of Articulating the World argues that a naturalistic account of conceptual understanding within the context of biological evolution requires understanding language more generally as integral to socially, discursively, and materially articulated niche construction. In bringing these two lines of argument together, I thereby seek to satisfy a central coherence condition for any philosophical naturalism: A naturalism that could not account for scientific understanding as part of nature as scientifically understood is fundamentally incoherent. Meeting this condition is not merely an obligation that must be met in order to sustain a viable philosophical naturalism, however. We gain a richer and more detailed grasp of scientific understanding and scientific practice by recognizing it to be an ongoing process of niche construction. Scientific niche construction involves coordinated changes that create new material phenomena, new patterns of talk and skillful performance, the opening of new domains of inquiry and understanding, and transformations
in what is at issue and at stake in how we live our lives and understand ourselves. The sciences thereby transform the world we live in and our place and possibilities within it. In doing so, they articulate the world to allow its conceptual intelligibility. Neither merely “made up” by us, nor found to have been already there, conceptual articulation is the outcome of new ways of interacting with the world that mutually reconstitute us as organisms and the world around us as our biologica. environment.12

In working out this reconstruction of the scientific image, several aspects of scientific practice receive heightened attention and reinterpretation as contributions to the conceptual articulation of our biological niche. Scientific research often requires creating novel phenomena (Hacking, 1983, 2009), prototypically in laboratories, but in my expanded sense, the field and observational sciences also bring new phenomena into play. These phenomena introduce new patterns into the world, which make different aspects of the world salient within our overall way of life. My discussion thus emphasizes a shift in how we think of the broadly empirical side of the sciences, from asking about what we can observe in the world to focusing upon what various phenomena can show us. Scientifically significant phenomena are structured events that allow patterns or relations to stand out as salient and significant. Observation may seem to be a private, experiential event, but phenomena are public, mutually accessible features of the world.13

In addition to arranging or uncovering new phenomena, scientists also build models of various sorts: analytical-mathematical, computational, physical, pictorial, diagrammatic, verbal, and more. Models are themselves internally structured systems, often ones that produce reliable responses to operations performed upon them. Juxtaposing these model systems to laboratory phenomena and more complex events also changes what is salient within the modeled events. Phenomena and models highlight the ways in which scientific conceptualization is a public, material process, in which meaning arises from patterned interactions within the world rather than from the internal, inferential relations among mental or linguistic representations. The point is not to deny the role of explicit judgments and inferences in scientific understanding, but instead to assimilate discursive articulation to the kinds of worldly patterns manifest in natural and experimental phenomena, and model systems of various kinds. Inferentially interconnected judgments and their constituent concepts are especially powerful model systems in just this way.

The modal character of conceptual understanding and scientific practice also requires heightened attention. Recent work on scientific practice has often de-emphasized the role of laws and nomological necessity (Beatty, 1995; Bechtel, 2006; Cartwright, 1999; Giere, 2006a; Teller, 2001). This shift away from conceiving scientific understanding in terms of laws has had multiple sources: a recognition that theoretical understanding is embedded in multiple, partial models rather than unifying principles; renewed attention to biology and other sciences that study historical contingencies rather than physical necessities; the waning of Humean skepticism about causal relations unmediated by lawlike regularities; the decline of the deductive-nomological theory of explanation and with it, a partial eclipse of the aspiration for a general philosophical theory of explanation at all. Yet these concerns turn out to be objections not to laws, but to specific conceptions of natural laws and their necessity. I argue in the book (following and building upon Lange, 2000, 2007, and Haugeland, 1998, 2013) that a more adequate understanding of laws highlights their indispensable role in scientific practice, and their important connections to measurement, inductive reasoning, and conceptual articulation, even in sciences such as biology, geology, or psychology that have often been mistakenly thought to lack laws of their own, on a narrower conception of what laws are.

Along with the aesthetic modalities, this account also gives greater emphasis to the normativity of scientific understanding. It is now a commonplace that the European history of modern science replaced an irreducibly normative conception of the world inherited from Greek philosophy with conceptions of nature in terms of causes, mechanisms, laws, or symmetries that leave no obvious place for normativity. In philosophical domains from logic to ethics and politics to aesthetics, normative considerations have consequently been construed as originating with us, as rational agents, social beings, affective perceivers, or makers of meaning. For naturalists who incorporate human life within scientifically understood nature, however, such relocations of normativity as instituted within our way of life only postpone the problem. If human beings are natural entities who can be understood physically, biologically, or psychologically, then our role as sources of normative authority and force must also be situated within a scientific understanding of nature.

Once conceptual understanding is situated within a biological context, any supposed abyss between nature and normativity seems to close. The way of life of an organism as a normative configuration of an environment is significant for the maintenance and reproduction of that way of life. In our case, what that way of life is, and thus how things show up as significant within and for that way of life, is itself at issue for us, rather than fixed as a relatively stable pattern. Our conceptually articulated way of life as human thereby allows aspects of the world to show up as significant in novel ways, and for other seemingly intelligible possibilities to be closed off or reconfigured. The sciences have been powerful examples of such conceptually articulated niche construction. Scientific research discloses new aspects of the world, new interrelations among familiar aspects, and new possibilities for our own self-understanding and way of life.

Normative considerations are central to scientific practice, since scientific understanding is highly selective. Which aspects of the world matter scientifically, which phenomena are worth exploring and understanding, and thus which inquiries are scientifically significant, are all integral to scientific understanding. Many responses to this recognition of scientific normativity have worked within the canonically modern conception that
situates norm-instituting human activity within an anormative nature. Such traditional approaches either take scientific significance to be determined objectively by an normative nature (e.g., determined by the generality of explanatory laws or the specificity of causal relations), or humanistically by our practices and interests. I argue that when we look more closely at scientific inquiry and the world it discloses, we find them to be normatively constituted in ways that cannot be reduced either to objective features of the world or to human imposition or institution.

As a naturalist, I am committed to understanding the normativity of scientific practice from within the horizons of the natural world disclosed within scientific research. One manifestation of this commitment has been the recognition of conceptual understanding in science as niche construction, a material transformation of the world that allows the world to show itself and affect us in new ways. Our conceptual understanding of nature does not and cannot take place from an imaginary standpoint outside nature that would allow us to represent it as a whole in an intra-linguistically articulated image. Scientific understanding is intra-worldly, and cannot transcend its own involvement in the world. Yet that involvement extends outward from scientific practices in the narrowest sense to encompass the place of scientific understanding within human life more generally. Conceptually articulated niche construction extends throughout the entirety of human life, and the sciences are important to us because of their integration within that larger set of issues, rather than because they are separate from it and relatively self-contained. In this respect, scientific understanding has to be understood within the contingencies of human history and culture. I thus take naturalism to be opposed to essentialist conceptions of science or scientific understanding. Scientific understanding is not a perennial possibility always available throughout human history, or even available to rational or intelligent beings of different biological species or different planetary ecologies. Sciences are historically specific practices emerging within human history. Moreover, that historical specificity reflects the biological specificity of language and conceptual understanding more generally.

This recognition of the historical specificity of scientific understanding brings us, at long last, back to the passage from Nietzsche with which I began. A naturalistic commitment to situating our self-understanding within the scientific image has sometimes seemed to challenge the authority and significance of scientific understanding, self-destructively. Philosophical understanding of science has often focused upon the sciences' supposed transcendence of the local and the human, precisely in order to understand the normative authority of a scientific understanding of the world. I think this aspiration to transcendence of our historical and ecological embeddedness has been erroneous, and has in any case been at odds with a naturalistic standpoint. Articulating the World concludes with a discussion of the contingency and locality of conceptual articulation generally and scientific understanding specifically. My aspiration is to show how science matters, and makes authoritative claims upon us, because of rather than despite its historical and cultural specificity. Science, as a powerful but historically specific extension of the conceptually articulated way of life that is our biological heritage, is not an essential possibility perennially available to any entities with sufficient intellect and social support. It is likewise not an aspiration to transcend our historical contingency through taking up a "god's-eye view" of ourselves and the world. Sciences are instead precarious and risky possibilities that only emerged in specific circumstances, and could disappear. The contingency of conceptual understanding generally and scientific understanding specifically does not thereby undercut the authority or significance of the sciences, but instead calls attention to what is at stake in whether and how those practices continue and develop. The contingent historical emergence and open-ended future possibilities for the subsequent development of scientific understanding should not be regarded as just one historical possibility among many, whose fate might be a matter of arbitrary indifference from the standpoint of the universe. We do not and cannot occupy such a standpoint. From the standpoint of those living a life in the midst of that history, these possibilities are the horizons for our lives, and for how our possibilities matter. Who we are and shall be, what our world is like and how it might further reveal itself, and what possibilities it might thereby open to us and our descendants or close off, are at stake in the subsequent development of our social-discursive way of life and the conceptually articulated manifestation of the world that it makes intelligible. Nothing could matter to us more, or be less arbitrary from a naturalistic standpoint, from within the world we aspire to understand.

NOTES

1. In talking about the Sellarsian Scientific Image as representational, I do not have in mind Sellars's more specific notion of representational "picturing", but the more general notion of scientific understanding embedded in its metaphorical characterization as an "image". Sellars to some extent divorces some of those connotations, but still holds onto a conception of scientific understanding as embedded in the epistemic product of inquiry as a body of knowledge. In a similar vein, he explicitly characterized the ideal limit of philosophical understanding:

To press the metaphor to its limit, the completion of the philosophical enterprise would be a single model...which would reproduce the full complexity of the [conceptual] framework in which we were once unreflectively at home. (1985, p. 296)

2. Articulating the World will include a much more extensive discussion of niche construction and its role in human evolution, in Chapters 8 and 9. Here is a brief summary of the conception for those unfamiliar with the basic idea:

Niche construction theory in evolutionary biology emphasizes how the developmental and selective environment of an organism is transformed by the ongoing and cumulative interactions of other organisms with that
environment; an organism's biological environment is not something given, but is instead dynamically shaped by its ongoing intra-action with the organism. Such transformations are not limited to enduring physical effects on the abiotic environment, for there can also be persistent forms of behavioral niche construction. Behavioral niche construction requires only that the presence of behavioral patterns and their selective significance for individual organisms' evolutionary fitness be reliably reproduced in subsequent generations. The emergence of communicative-cooperative practices that evolve into language can then be understood as a preeminent example of niche construction. Language is a persisting public phenomenon, which develops and co-evolves with human beings. Human beings normally develop in an environment in which spoken language is both pervasive and salient, and languages only exist in the gradually changing forms in which they can be thus learned and reproduced. Our ability to acquire and take up the skills and discriminations that enable the ongoing reproduction of that phenomenon is then integral to our overall practical/perceptual responsiveness to our environment, which has become a discursively articulated environment. The evolutionary emergence of this capacity, and its ontogenetic reconstruction in each generation, relies on the close coupling of organisms' capacities for perceptual and practical responsiveness to their environment. There is nothing mysterious or even discontinuous about the gradual development of the linguistic capacities and performances that enable conceptual understanding. Yet the partial autonomy of discursive practice due to its systematic interconnectedness with other aspects of our perceptual-practical immersion in an environment allows for the emergence of symbolic displacement and conceptual understanding.

Conceptual understanding thus emerges biologically as a highly flexible, self-reproducing and self-differentiating responsiveness to cumulatively constructed aspects of our selective environment. Discursive niche construction is not limited to our abilities to perceive and produce linguistic expressions. Other expressive capacities (pictorial, musical, corporeal, and more) have emerged in the wake of language. More important, however, is that the resulting capacities for symbolic displacement also come to incorporate our broader practical-perceptual immersion in an environment. Our perceptual and practical capacities are not themselves different in kind from those of other organisms, but they are transformed by their uptake within discursive practice. The possible discursive significance of everything we do has been prominently characterized by McDowell (1994) as "the unboundedness of the conceptual". Our discursively articulated practical/perceptual involvements are pervasive throughout and integral to the world in which we develop as and into adult human beings. Their cumulative effects have dramatically transformed us as a species, and indirectly affected many others, including many driven to extinction. Yet the proximal marks of the discursive articulation of the world, however salient and significant for us, are environmental features to which our various "companion species" (Haraway, 2008) are almost entirely insensitive. Our inherited responsiveness and massive ongoing contribution to this peculiar cumulative history of niche construction, and not any general cognitive capacities, are what differentiate us as concept users from any other known organism.

3. In the book, I discuss the ways in which scientific practice draws upon the conceptual and practical resources of its broader cultural setting. In the context of the present discussion, I would only note that the establishment of controlled experimental systems as the locus for the articulation of conceptual domains draws upon the much broader effort to establish and maintain standard units of measurement, and to extend beyond the laboratory setting the isolations, purifications, shielding and so forth that enables experimental phenomena to manifest clear and intelligible patterns in the world.

4. Strictly speaking, as Putnam (1975) prominently called to philosophical attention, the division of linguistic labor allows people to talk intelligibly about all sorts of things that they are not themselves capable of telling about in this sense, or telling apart. Yet someone must be able to tell what is being talked about in some domain of discourse, if such talk is not to become a "frictionless spinning in a void" (McDowell, 1994). Enabling and sustaining such conceptual engagements: the world is a central part of what the sciences accomplish.

5. For a useful discussion of what is at issue in understanding a domain as a system in which distinct components interact at well-defined interfaces, see Haugeland, 1998, ch. 9, and Simon, 1969.

6. For more extended discussion of experimental systems, and their role in conceptual development, see Rheinberger, 1997; Rouse, 1987 (esp. ch. 4), 2009, 2011.

7. Recognition of the ways in which the development of scientific institutions has been integral to our conception of scientific understanding affects how we think about the history of science. Recent work in the history of science (Biagioli, 1993, and Shapin & Schaffer, 1985, are especially influential examples) highlights the ways in which very important scientific accomplishments arose in contexts with a quite different sense of the aims and significance of scientific research, which were also contested at the time. The point of such work is not to reject our contemporary sense of Galileo’s or Boyle’s accomplishments as anachronistic, but instead to highlight the ways in which what it is to do science, and to understand the natural world, has been shifting in the course of ongoing inquiry.

8. Empiricism upon the differential reproduction of scientific skills and understanding is important. Although scientific practices and understanding are sufficiently continuous over time to talk about their reproduction, we should recognize that concepts, skills, practices, and materials are continually being reconfigured and re-conceived in the course of their transmission.

9. Daston and Galison’s (2007) important study of changing conceptions of objectivity expressed in scientific atlases and handbooks usefully highlights the fact that epistemologically potent concepts such as “objectivity” are not merely terms for philosophical reflection upon science, but also terms that function within scientific practice to shape the direction, form, and content of scientific work. Yet they do not explicitly call attention to the prospective orientation of such works, as preparation for encountering and making sense of novel cases, even though the importance of this role for such works shows up throughout their discussion.

10. I use “justification” here in a broad sense that incorporates relational accounts of the authority of scientific knowledge. My point is not to distinguish internalist accounts of reasoning and justification from externalist accounts of reliable methods and strategies of inquiry, but to highlight the focus of both upon a mostly intralinguistic domain of statements or propositions. Reliabilists are usually as much concerned with the reliability of scientific knowledge claims (even if that reliability is grounded in scientific methods and the perceptual or instrumental detection of entities and their properties), as internalists are with the (more narrowly conceived) justification of knowledge claims by other statements or propositions.

11. There is a crucial role for reasoning and justification even in relational accounts of knowledge, since the reliability of various methods or procedures is always indexed to a reference class within which they are or are not...
reliable, and the determination of the relevant reference class cannot itself be understood in reliabilist terms (Brandom, 1994, ch. 4; 2000, ch. 3).

12. Strictly speaking, a naturalistic position understood in this way cannot talk about the world as a whole, which is only then differently configured as a meaningful environment by the way of life of various organisms. There are only these interlocking environments that allow meaningfully configured manifestations of a world. Yet there is another way to vindicate talk of the world as it is apart from its significance for us. The “environment” of an organism is not an enclosed space with an “outside” to it. Entities that do not matter to an organism’s way of life are not “outside” its environing world, but are only relatively opaque to its life activities. These forms of opacity and transparency are also mediated by other organisms, since what does not affect an organism directly may nevertheless figure prominently in the developmental and selective environments of other organisms that do matter to it. Moreover, these significance relations are open to change, since environments are dynamic. An organism like us, whose way of life is discursively and thus conceptually articulated, thematizes this possibility of disclosing aspects of the world previously hidden from it. Thus, from within our way of life, we understand and comport ourselves toward possibilities of the world being more or other than it appears selectively within our own way of life. The notion of an “objective” world, a world as it is apart from its meaningful configuration within any specific organism’s way of life, thus should not refer to an already determinate configuration of entities, but to an issue we confront within our ongoing conceptually articulated way of life.

13. In fact, observation is never merely a private, experiential event, but always situates perceptual and practical responsiveness within a larger pattern of material-discursive practice, including the ways in which we call others to share in our observational discoveries (Kukla & Lance, 2009).

14. There is no necessary tension between essentialist conceptions of science as a perennial possibility within human life, and a recognition of the vulnerability of a scientific ethos and the way of life it sustains. One might think of the conceptual and epistemic norms of the sciences as always making claims upon us, even though recognition and uptake of those claims is at risk. I will nevertheless be making a stronger claim: the normative authority of scientific practices, concepts and claims only emerges within an historically and biologically specific context, such that maintaining that authority requires also sustaining the way of life within which those practices, concepts and claims could be authoritative for us. Recognizing the contingency of scientific practices and norms does not undercut their authority, I argue, but instead intensifies the significance of what is at stake in sustaining a scientific way of life. There is nevertheless an important insight in essentialist conceptions of the normative authority of the sciences. They are best understood not at face value as descriptions of the “nature” of science, but are instead efforts to focus what is at issue in specific conflicts or tensions over the maintenance of the intelligibility of a scientific way of life and a scientific culture as we know it. They should thereby be themselves understood as an important aspect of a scientific way of life. They are situated, reflective efforts to articulate who we are, how we live, and why it matters to sustain that way of life, from within its horizons. In doing so, they help sustain, and to some extent transform, that way of life in bringing its normative claims and their authority to reflective attention.

Is Rouse’s Scientific Image Really Scientific?
Commentary on “Scientific Practice and the Scientific Image”, by Joseph Rouse

Emiliano Trizio

In his complex paper, Joseph Rouse takes up Wilfrid Sellars’ claim that one of the central issues in 20th-century philosophy lies in the challenge of recombining the image of the world developed by science, the “scientific image”, with the so-called “manifest image”, in which we appear as personal subjects answerable to norms. Rouse believes, however, that both images must be revised in order to succeed in developing the wished-for stereoscopic vision in a satisfactory naturalistic framework. In particular, and this is the topic of his paper, it is our understanding of the scientific image that must be deeply modified in order to serve this purpose. In this vein, Rouse’s paper addresses the theme of this volume by asking: “How would an emphasis upon science as practice revise the scientific image, in its dual sense of a scientific understanding of the world and a conception of scientific understanding”? (Chapter 9, this volume, p. 278). Let us stress at once that: 1) According to Rouse (and coherently with his naturalistic stance), the scientific image must include a conception of scientific understanding itself; 2) the practice turn allows revising the scientific image in such a way that it includes a correct “scientific” understanding of scientific understanding itself.

Rouse begins by addressing possible qualms coming from the side of the so-called “disunifiers”—that is, those among the advocates of the practice turn who argue that science should not be seen as producing an image of the world at all. Yet the dis-unifiers, just like Sellars, believe that scientific understanding is based on representation. The dis-unifiers thus conclude, contra Sellars, that there is no “scientific image” of the world, in the sense of a single unified scientific representation of it. Rouse points out, instead, that what the practice turn really teaches us is that scientific understanding is not primarily representational, while naturalists themselves have so far tried to naturalize scientific understanding by naturalizing mental or linguistic representations. The outline of Rouse’s anti-representationalist account of science can be captured in terms of a series of oppositions between the old philosophical understanding of science and the new understanding issued from the practice turn. According to the old view: 1) Scientific understanding consists in an empirically justified fabric of beliefs, or in a position in an intralinguistic space of reason; 2) scientific understanding is disembodied