Seeing the Unobservable:

Van Fraassen and the Limits of Experience

I. Introduction

> "We can and do see the truth about many things: ourselves, others, trees and animals, clouds and rivers—in the immediacy of experience."[1]

Absent from Bas van Fraassen's list of those things we see are paramecia and mitochondria. We do not see such things, van Fraassen has long maintained, because they are unobservable, that is, they are undetectable by means of the unaided senses.[2] But notice that these two notions—what we can see in the "immediacy" of experience and what is detectable by means of the unaided senses—are not the same. There is no incoherence in maintaining that the immediacy of experience is capable of disclosing to us truths concerning entities that are not detectable by the naked eye. And so, I claim, it does; science and technology provide us with the means to see things we have never seen before. Some of those things are van Fraassen's unobservables.

That suggestion is nothing new. Grover Maxwell long ago emphasized the continuity between seeing with and without instrumentation.[3] Van Fraassen originally provided two responses to Maxwell's arguments: some things that you can see with instruments you can also see without instruments (and those are the observables); and

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[1] van Fraassen 1980, 178.
[2] van Fraassen 1980, 13-19.
[3] Maxwell 1962.

vague distinctions are still legitimate distinctions (or at least are not illegitimate on those grounds alone).[4]

There are counters to each response, and the battle rages on.[5] But the war consists, for the most part, in either a clash of intuitions concerning whether we really see this or that, or it concerns ancillary issues (whether the vagueness is something van Fraassen can live with given his use of the distinction, for example[6]). These issues, important as they are, do not address what seems to me a more directly relevant question, namely, what the requisite conditions are for us to see something. Surely this question needs to be addressed before approaching the more specific question whether we can see something when we use instruments.

Ian Hacking has emphasized the fact that familiarity with microscopes gives one a dramatic sense of the reality of what one (apparently) sees when one looks through them.[7] The cases he discusses—the shrinking grid, for example[8]—are striking. But it does not seem to me that Hacking has expressed very clearly why they *are* convincing, or why they should be. Some of his comments—concerning the fact that we see what appears to be the same thing using different imaging techniques, for example—are little more than appeals to common cause or best explanation.[9] These comments are

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[4] van Fraassen 1989, 13-19.

[5] See, for example, Foss 1983, Churchland 1985 (and, to various degrees, most of the articles in Churchland and Hooker 1985), Seager 1995, and Vollmer 2000.

[6] See, for example, Foss 1983.

[7] Hacking 1983 and 1985.

[8] See Hacking 1985, 146-148.

[9] Notwithstanding Hacking's protests to the contrary; see Hacking 1985, 145-146. His argument is distinct from the standard best-explanation-of-science's-success argument. But it seems natural to construe his argument from coincidence as that the correspondence between images produced by distinct imaging techniques is best

disappointing because they bring Hacking's very interesting discussion of experimental instrumentation back to the common line of realist argumentative strategy, to which van Fraassen has already responded.

At any rate, I intend to approach the issue in a way that does not engage with either the neo-Maxwellian arguments or Hacking v. van Fraassen. I do ask a question that Hacking has asked, namely, whether we see through a microscope. Hacking answered in the affirmative; but his investigation emphasized the "microscope" part of the question. I would like to emphasize the "see" part.

II. Realist as Rationalist

The claim that we can only see what the human senses can detect without aid or supplementation of some sort is not a conceptual truth; or, if it is, it is far from obvious that it enjoys that status. Nor is the claim obvious from a review of intuitive judgments concerning what we can see. Whatever else Hacking's examples might do, they provide a body of examples that push our intuitions in the other direction. Van Fraassen needs an argument. Indeed, he needs a philosophy of perception; that is, an account of perceptual processing that is capable of delivering an answer to the question whether aided seeing is still seeing (and which answer would, of course, have to be "no").

Van Fraassen sets the issue up in a way that suggests that there really is not much to discuss, as it is pretty obvious in the cases that he emphasizes that we do not really see the unobservable in question. His paradigm example is that of a particle's passage

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explained by the existence of a suitable microscopic entity that is causally responsible for them.

through the cloud chamber.[10] We sometimes say that we see the particle passing through the chamber, much as we might say that we see the airplane's passage by observing its vapor trail. But we do not of course *really* see the particle (or the plane); if pressed, we would say that we only really saw the trail, and assumed (or inferred) the rest.

But since the trail is really the only object seen, something else entirely might be behind—or, in this case, in front of—the trail, quite compatibly with what is in fact seen. So the question arises: do we really know that the agent responsible for the trail *was* a particle (plane)? Now the two cases come apart: the plane might make a lower pass and come within visible range. So we can check on the plane-trail relationship. But the particle can never come within visible range; and the same is true for all its fellow particles. But then how would we ever know that we were right? And why would it matter? Are scientists in fact really that concerned about whether the particle-hypothesis is right, or are they only using a useful analogy to keep track of the trails? And so on.

This case is a model for a general conception of the (putative) relationship between ourselves and unobservables: whenever we "see" unobservables—insofar as it is appropriate to speak this way—we only do so indirectly, that is, by seeing something else that is observable (and that something else is the only thing that we really do, in fact see, as we would affirm if pressed).[11] This is, no doubt, the right way to think about the cloud

[10] van Fraassen 1980, 16-17.

[11] Van Fraassen is not the only one to interpret the relation between observables and unobservables this way. See Sober 1993, 54: "I begin with what I regard as a truism: *when something is unobservable, the only way we can find out about it is by finding out about something that is observable.* Electrons are too small to see. So we use instruments. We usually encounter few problems in seeing what state a measuring device is in; we then infer from the state of the measuring device what state the electrons occupy in the experiment" (italics in the original).

chamber and the plane.[12] If it is the right way to think about unobservables in general (again, in van Fraassen's sense of the term), then we find ourselves with a two-world image. There is the observable world, populated by certain sorts of entities, and concerning which information floods in when we open our eyes. And there is the unobservable world, populated with different entities, concerning which we can only make guesses—educated guesses, the realist contends, merely comforting, counters the constructive empiricist—without ever finding out whether any of those guesses are right.

This picture is rather bleak; one gets the sense that realists are deeply disturbed by it.[13] Whatever the status of inference to the best explanation (or whatever other inferential tool might be used to leap over the fence into unobservable territory), it does smack of an uncomfortable reversion to rationalism to put it to this apparently desperate purpose. Experience provides a window only on the observable realm. So we have to assemble the facts concerning that realm that experience provides, wave an inferential wand over them, and suddenly the wonders of another world entirely—the reality "behind" the phenomena—are thereby revealed to us.

Admittedly, those intellectual powers operate on empirical information rather than delivering the rationalists' pure insight *ex nihilo*. But the idea that ratiocination on information concerning one domain will generate information about an entirely different domain is not so distinct from classical rationalism. After all, one might argue, the recognition that cognitive manipulation of empirical information generates information about the super-empirical could not itself be the result of either empirical information or

[12] That claim also, however, presupposes a theory of perception.
[13] Indeed, one finds them resorting to some unexpected maneuvers, such as Alan Musgrave's willingness to add a "dash" of pragmatism to his realism (Musgrave 1985), or Brian Ellis' advocacy of internal realism (Ellis 1985).

cognitive manipulation of empirical information, on pain of regress. It seems that only a pure form of rational insight can ground the cognitive manipulation of empirical information which gives us access to the unobservable realm.

That realism requires this rationalistic end-run around experience is, I think, van Fraassen's fundamental challenge to his realist opponents, although he does not make that challenge entirely explicit. Nor is the challenge explicitly met, or clearly recognized, by realists. I do nonetheless think that realists have a somewhat inchoate sense of the charge and this is one reason why they find constructive empiricism disturbing. Realists are not empiricists in van Fraassen's sense; but they are empiricists in the sense opposed to rationalism.[14] Van Fraassen insists that, in venturing past empirical adequacy, the realist has left the solid empirical ground behind and indulges in flights of intellectual fancy with no more constraint or guidance than his inferential predilections impose. The realist then has the audacity to suggest that anyone refusing to follow his trajectory, or who chooses another one, is irrational. When realism is so characterized, the charge that it is committed to an overblown rationalism is understandable; for that is the sort of

[14] "Traditionally, empiricism has been opposed, not to scientific realism, but to rationalism, and to revelationism, as a theory about the *sources* of our knowledge. And most scientific realists would agree with empiricists on this issue . . . . Nevertheless, the disagreement *within* the empiricist tradition about the aim of science is an important one, and I see no point in arguing about labels." Ellis 1985, 48. Van Fraassen's response to Ellis here is the closest that van Fraassen comes, so far as I am aware, to explicitly issuing the charge of rationalism that I suggest underlies his critique of realism: "I do not consider leaps of faith or belief in things unseen, arrived at for whatever reason, necessarily irrational—only the pretense that we are rationally compelled (e.g., through arguments concerning explanatory value) to embrace more than strict empiricism prescribes." van Fraassen 1985, 286.

presumptuous behavior exhibited by past rationalists that has often been subject to ridicule.[15]

III. "Phenomena" Revisited

The two-worlds view, and consequent charge of rationalism, presupposes that the cloud-chamber model—wherein experience delivers us information concerning unobservables, if at all, only by presenting us with observables and leaving us to do the rest—is a good one for our relationship to (van Fraassen's) unobservables generally. This is not, however, a model that naturally fits such an instrument as the microscope. There is, after all, no intervening observable between eye and slide whose inspection at best reveals observable manifestations of a distinct underlying cause. The microscope itself, of course, does intervene, and it is an observable. But we are not looking *at* the microscope. We are certainly not noting features of the microscope that we take to be correlated with features of the object mounted on the slide. We are looking *with* it, *at* the object on the slide. That is, at any rate, the description of the situation that suggests itself. Van Fraassen needs to both present an alternative description of the situation more congenial to his purposes, and motivate the adoption of that alternative notwithstanding the intuitive force of this representation of the situation.[16]

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[15] It is, however, by no means clear that constructive empiricism itself, in extrapolating from what has been observed to what is observable, is not thereby subject to the same criticism. See Alspector-Kelly 2001. Concerning the general question whether empiricism is coherent without any *a priori* assumptions, see Nagel 2000.

[16] "We use microscopes to become aware of paramecia, mitochondria, cell walls . . . , not to produce images of which we separately become aware and then interpret as images of these things." Teller 2001, 133.

He has lately done the former.[17] He suggests that we understand the microscope, not as a "window" on an otherwise unobservable scene, but as generating new (observable) phenomena. This requires the expansion of the concept of empirical phenomena familiar from *The Scientific Image*. According to the earlier account, the empirical phenomena were identified with the truth concerning observable objects.[18] But we are *not* to construe the view through the microscope as the sighting of an object; and there is no other observable object to hand. Empirical phenomena now include *images,* which are, roughly, reifications of entities that we seem to see but that do not exist (or might not exist, for all we know).

In way of illustration, van Fraassen asks us to consider such phenomena as the rainbow. We refer to the rainbow as a real object that we commonly view, and to which we point with extended arm and fingertip. Nonetheless, we do not literally see a rainbow. We can only see what exists; and rainbows—physical, multi-colored arches across the sky—do not exist. The rainbow is an illusion. In particular, is a public illusion, as opposed to private hallucinations, afterimages, and the like. It is even photographable. There is, nonetheless, no such *thing* as the rainbow. It is merely an hypostatized creature of our perceptual circumstances.

Van Fraassen suggests we construe the view through the microscope similarly. More precisely, and in line with his general agnosticism, he points out that our view through the microscope might be the sighting of a real object or a public illusion akin to the rainbow. He insists that neither our experience nor our discourse and practice will tell against the latter possibility just as he earlier insisted that neither our experience nor our

[17] van Fraassen 2001.
[18] van Fraassen 1980, 18.

discourse and practice can tell against the hypothesis that there are no unobservable objects in addition to the observable ones.

We know that the rainbow is an illusion, in part, because it does not behave properly. Its apparent location varies with the observer's point of view, for example, in a way that physical objects cannot. But the putative blood cell seen through the microscope is well-behaved, so far as we know; in this way the analogy with rainbows breaks down. Van Fraassen cheerfully admits this, and points out that the cell might still be an illusion for all that, if a more convincing one.[19] We do not, admittedly, have the reason to believe that the cell does not exist that we have for denying the rainbow's existence. But lack of a reason to believe in the non-existence of something is not a reason to believe in its existence.

That is correct. But mere possibilities should not necessarily be given equal weight. The sense that one really is looking at something real when one looks through the microscope at a cell remains phenomenologically irresistible, and nothing counts against construing the situation this way as there is in the case of the rainbow. Why, then, resist?

Here is van Fraassen's answer:

> Of course there is one major difference that springs to the eye. If you see a reflection of a tree in the water, you can also look at the tree and gather information about the geometric relations between the tree, the reflection, and your vantage point. The invariances in those relations are precisely what warrant the assertion that the reflection is a picture of the tree. If you say similarly about the microscope's images that they are pictures of e.g. paramecia, then you are asserting that there are certain invariant geometric

[19] "The difference, that we cannot think of the rainbow as an image of a real arch, while we can think of the microscope image as of a similarly structured object, is important but irrelevant for my point." van Fraassen 2001, 157.

> relations between the object, image, and vantage point. But now you are *postulating* that these relations hold, rather than *gathering information* about whether that is so.[20]

You are postulating that these relations hold in the former case because you enjoy image-independent access to the tree—by looking directly at it—that is not available to you in way of evaluating the validity of your view through the microscope. William Seager, anticipating van Fraassen, calls the information gleaned from unaided observation the "ground truth" that can be used to calibrate more indirect imaging techniques.[21] The difference between the tree reflection and the microscope is that ground truth is available in the former case but not in the latter.

An obvious counter is to point out that when we look directly at the tree we are *also* postulating an appropriate relation between object, image, and vantage point, namely, the tree itself, our perceptual experience of the tree, and the vantage point of our bodily location.[22] As van Fraassen puts it, an experience is an event which "has two sides, so to say: what really happens to me and the spontaneous judgment I make in response, which classifies that event in some way."[23] It is because these can come apart that van Fraassen can claim that we do not know whether we might be really seeing objects on the microscope slide or only subject to a public illusion, and that our spontaneous inclination toward the former does not settle the matter. But this duality has nothing to do with whether we are (putatively) looking at something through a microscope or (putatively)

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[20] van Fraassen 2001, 160.
[21] Seager 1995.
[22] Actually, I think it is misleading to suggest that we are *postulating*—paradigmatically, a conscious cognitive act—in either case. But the point is that we have as much reason to describe the direct view of the tree this way as we do its image in the water.
[23] I agree that there are two sides, but do not entirely agree with van Fraassen's characterization of the perceiver's side. It is the perceiver's experience that lies on that side, not the judgments, however spontaneous, the perceiver makes in light of it.

looking at something with our eyes. As the rainbow example illustrates, there are the same two sides to our experience whenever we simply look around. Perhaps rainbows *and* elm trees are public illusions, the latter having been uncritically accepted as real only because they do a better job of imitating true physical objects than do rainbows. As van Fraassen points out, an image's imitation of objectivity, no matter how flawless, is no guarantee of its physical reality.

IV. An Earlier Response

Van Fraassen's earlier response to such concerns in *The Scientific Image* (SI)—that observables might be as "hypothetical" as unobservables—is that such a view presupposes the coherence—and existence—of sense-data or some other reification of an inner stream of experience. Such concerns were not, he thought then, worth the time of day, since "philosophers spent the first five decades of this century refuting the presuppositions" that lie behind the introduction of these ill-conceived creatures of armchair psychology.[24] Van Fraassen is an agnostic regarding unobservables, but sense-data, he was sure, "do not exist."[25]

This response itself presupposes that empirical phenomena must be identified with the truth concerning some domain of empirically accessible entities. Otherwise, the claim that observables are "hypothetical" would not require more empirically immediate

[24] van Fraassen 1980, 72.
[25] van Fraassen 1980, 72.

sense-data to function as evidence for the observable-object hypotheses. That presupposition was consonant with his identification in SI of empirical phenomena and the truth concerning observables, sense-data having been decisively repudiated as candidate entities to play that role.

In light of van Fraassen's recent extension of the concept of empirical phenomena to include the rainbow and its ilk, this response won't do. Images and illusions are empirical phenomena without empirical objects. Even if we have no other way of describing them except as objects—as seems the case with the rainbow—that does not require that we take such talk as committal. It therefore requires no more commitment to sense-data than does the possibility that microscope-viewings are public illusions.

There is a certain irony here. The assumption that empirical phenomena require empirical objects, which van Fraassen's SI-era argument against sense-data presupposed, was itself assumed in an influential argument *for* sense-data. In light of such illusions as the rainbow, it did not seem possible to straightforwardly identify the objects of our experience with material objects—there is, after all, no material object with which the rainbow can be identified. But—here is the assumption—there must be something that we *are* seeing when we seem to see a rainbow. Sense-data—which *are* how things *seem*—were expressly designed to fit the bill. Given the assumption that van Fraassen of SI apparently shared with the sense-datum theorist—that observation is always of observables—and in light of the rainbow and similar illusions, it is no easy matter to avoid this argumentative path to sense-data. Van Fraassen could hardly have denied that such phenomena occur or that they fall within the purview of scientific inquiry. The assumption that van Fraassen tried to wield against sense-data should really, given the

resources available in SI for characterizing empirical phenomena, have led van Fraassen to their affirmation.

However that may be, van Fraassen's inclusion of images—object-like experiences without empirical objects experienced—among empirical phenomena renders irrelevant this concern with van Fraassen's SI argument against sense-data. But also irrelevant is an appeal to observation without instruments as ground truth. Naked-eye observation is as susceptible to a failure of fit between the experiencer's spontaneous judgment and what is happening to him as is the view through the microscope; there is no ground truth that does not rest on the "postulation" of appropriate relations between object, image, and vantage-point. Van Fraassen's dichotomy between postulation-free information-gathering by the naked eye and postulation-laden microscopic imagery is spurious.

That is, it is a spurious dichotomy unless van Fraassen has some *independent* reason to believe that naked-eye observation is a reliable source of information in a way that observation through a microscope is not. Notwithstanding the variety of instruments of observation at our disposal, he believes that we do not see the truth about such things as paramecia in the immediacy of experience. But why not? His disparate treatment of views through a microscope as mere imaging and naked-eye observation as truly seeing just begs the question against the view that there is no significant difference between the cases that could underwrite that disparate treatment. Without an argument, van Fraassen's position amounts, at best, to an unreasoned distrust of perceptual enhancement technology, and at worst, to a rejection of a tremendous amount of empirical information that, thanks to technological ingenuity, our senses immediately provide.

Notwithstanding the fact that the two-worlds view, the overblown-rationalism objection to realism, and the very coherence of constructive empiricism depend on it, van Fraassen has never, to my knowledge, provided such an argument. We are therefore on our own to distinguish what truths we can see in the immediacy of experience (if any) from what we cannot (if any).

V. Inadequacy of the Pragmatic Theory

As a point of departure, consider van Fraassen's way of drawing the observable/unobservable distinction. He advocates the "pragmatic" theory of observation that he inherited from Feyerabend and Sellars.[26] According to that model of observation, what is observable is what, according to the best scientific information we currently have, is detectable by means of the human senses without instrumentation. "The human organism is," van Fraassen said in SI, "from the point of view of physics, a certain kind of measuring apparatus. As such it has certain inherent limitations—which will be described in detail in the final physics and biology."[27] Here is his characterization of a measuring apparatus:

> We call a system Y a measurement apparatus for quantity A exactly if Y has a certain possible state (the ground-state) such that if Y is in that state

[26] van Fraassen did not refer to the account in these terms in van Fraassen 1980. But he acknowledges the term and heritage, and discusses the account in more detail, in van Fraassen 1992, 14-20.
[27] van Fraassen 1980, 17.

> and coupled with another system X in *any* of its possible states, the evolution of the combined system (X *plus* Y) is subject to a law of interaction which has the effect of correlating the values of A in X with distinct values of a certain quantity B in system Y.[28]

The limitations of a measurement apparatus are then presumably determined by the limitations of the law of interaction. Perhaps the correlation is good enough to employ as a fairly reliable source of information, but less than perfect. Perhaps only values of A within a certain range are correlated with values of B. Perhaps neither this law nor any other correlates values of another quantity C in X with any quantity in Y. Perhaps there are no laws that correlate *any* quantities in X with a quantity in Y. These are, of course, limitations to which the human organism as measurement device is subject, falling short of perceptual omniscience as we do.

In the human case, Y is the human sensory apparatus, X the object sensed, and A a discernable property of X. There is some ambiguity here with respect to Y. If by "sensory apparatus" one means the receptor neurons, then a certain discernability threshold results; rods in the eye, for example, are capable (remarkably) of registering single photon-hits. But a single photon hit is typically not *perceptually* discernable. Rods, cones, and other neurons have a background spontaneous firing rate, for example, "noise" which the "signal" of neuronal activity in response to such hits must overcome in order for the brain to register incoming light and so in order for us to experience it.[29]

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[28] van Fraassen 1980, 58-59.

[29] The relation between signal and noise in perception is the topic of the Signal Detection Theory. See Schiffman 1996, 25-32.

Given his epistemic purposes, van Fraassen would presumably favor perceptual detectability over neural-receptor sensitivity, the thresholds studied by the psychophysicist rather than by the neurophysiologist. It is only the former with which we are presented in the immediacy of experience, after all, there being no direct representation of the pattern of receptor-neuron firing in perceptual experience. Van Fraassen seems to think that only biology and physics are required in order to describe the limits of observation. But the details described in the final science must include perceptual psychology alongside biology and physics.

Notwithstanding this correction, the pure detector model is inadequate for van Fraassen's purposes (and as a theory of perception). This is because there are no constraints on the *character* of quantity B that is correlated with quantity A.

Mark Wilson points out that "[i]f I train you to waggle your head in a certain way and report whether you've seen a yellowish image, you will thereby be serving as a fairly reliable detection device for the direction of polarization of the sky's light . . . ."[30] We would nonetheless hardly say that you *observe* or *perceive* the polarization. The relationship holding between the character of one's perceptual experience and the properties of objects cannot merely be that of lawful correlation. *That* relationship *does* hold between the particle and the viewing of the trail in the cloud chamber: assuming that the observer's eye is suitably situated with respect to the cloud chamber apparatus, a lawful relationship holds between 1) the passage (and therefore existence) of the particle through the chamber and the trail and between 2) the trail and the impact on the observer's perceptual system, and therefore between 3) the passage and the impact on the

[30] Wilson 1985, 230.

observer's perceptual system. That this relationship holds in this case tempts us to speak of ourselves, loosely, as seeing the particle. Nevertheless, van Fraassen is, I think, right when he says that we do not really do so.

Moreover, the medium of transmission itself can play the role of detected property; color-vision is lawfully correlated, not just with the characteristics of reflective surfaces, but also with physical characteristics (wavelength, intensity, etc.) of the light reflected.[31] But van Fraassen insists that light itself, as opposed to the surface reflecting it, is not observable.[32]

Indeed, every experimental set-up, however different the input (internal temperature of a distant star, say) and output (photon-hits on the retina sent from the computer's screen as an array of numbers marches across the monitor), just *is* an arrangement that (if successful) ensures that values of the entity under investigation are lawfully correlated with changes in perceptual experience. But then van Fraassen would have to countenance every experiment, however small, far, or otherwise remote the subject-matter, as an instance of observation of that subject-matter. He cannot do that. Nor should he; perception does not have so wide a reach as this.

Van Fraassen might counter that he is concerned with *unaided* perception as a measurement system; and one's eyes cannot, without a lot of apparatus, detect the internal temperature of a star. But that misses the point. There is nothing in the pragmatic

[31] This relation is by no means a simple one; it is logarithmic, and subject to a variety of contextual factors. But it remains lawful once those aspects are taken into account, as it must be if light is to be capable of delivering information concerning the perceiver's environment.

[32] van Fraassen 2001, 150-154.

theory of observation that rules out construing the experimental setup as the mechanism by which system X (the star) is coupled to system Y (the observer). The aided/unaided distinction is simply foreign to the classification of a system as a measurement apparatus, so long as the requisite correlation holds between target and measurement systems. And anyway, correlations between color-vision and those characteristics of light that van Fraassen counts as unobservable are not "aided" in any way, but those characteristics are observable on the pragmatic theory nonetheless.

I do, however, think that the idea that perception involves lawful correlation between states of the world and states of the perceiver's perceptual system is fundamentally sound.[33] The issue is then whether the pure detector model can be adjusted to avoid these inadequacies. How can this be done?

Two points before making the attempt: first, I will continue the discussion in the "naturalistic" mode, that is, taking as given the results of contemporary research on the physics, physiology, and psychology of perception. I am "allowed" to do this, at least given the dialectical purposes of this essay. While the constructive empiricist does not *end* with contemporary scientific image in all its details, he *begins* there. The contemporary theoretical description of our physical selves in the physical world is the point of departure for the determination of our sensory limitations, and therefore of the observable, and therefore of empirical adequacy, and therefore of the limits of the constructive empiricist's doxastic commitment to that description.[34] So van Fraassen cannot, prior to the settling of issues pertaining to observation and the limits of

[33] More accurately, I think that veridical perception requires the existence of a causal relation between perceiver and perceived underlying that correlation.
[34] See van Fraassen 1980, 59.

experience, object to the use of the full-fledged scientific image, neurons, photons and all.

Second, the purpose is to understand how perception, as a psycho-physical process, delivers us information about the world. So informationally irrelevant distinctions should not be made out to be fundamental in drawing the limits of experience. (The significance of this latter point will be apparent as we go.)

VI. Deciding What We See

Automobile side-door mirrors sometimes display the warning that "objects in mirror are closer than they appear," thereby revealing the manufacturer's opinion that the mirror provides a view of the physical object behind the vehicle. One might protest that the object seen *in the mirror* is not the reflected object (and could not be smaller than it appears), since objects seen must be in front of the viewer's eyes. Is the object viewed "in" the mirror identical to the physical object reflected in it or a distinct "image"? Do mirrors allow us to see objects other that those in front of our eyes?

Baby monitors, telephones, closed-circuit televisions, live radio and television broadcasts, hearing aids, night-vision goggles, and a variety of other instruments bring sights and sounds to us by unusual causal paths. In each case, the original light- or sound-waves reflected or emanating from the object are transformed into electromagnetic pulses or streams of electrons and then transformed back into distinct light- or sound-waves which proceed to impact our sensory receptors. We are nonetheless quite comfortable

with the suggestion that we hear the crying baby through the monitor, the friend on the telephone, the customer at the ATM machine on the closed-circuit television, etc. Are we, in such cases, subject to a kind of pervasive illusion, taking ourselves to see and hear objects and events that really stand in a relation distinct from that between perceiver and perceived? Or do we really see and hear what we claim to see and hear? (Notice that the issue does not merely concern spatio-temporal dislocation; someone with normal hearing will identify and locate objects heard while wearing a hearing aid as they would without one.)

Opaque three-dimensional objects obscure their own farther side from our view; we can never see all of an object's exterior at once (putting aside the issue concerning mirror images for the moment), which object we nevertheless claim to see. But a brief glimpse of two hairs on the tip of a dog's tail will not typically count as a dog-viewing. How much of an object must lie within unobscured view for the viewer to count as seeing it?

If one has misplaced one's glasses, or peers through dense fog, or attempts to identify someone across a dimly lit room, one's view is less than ideal. How uncooperative must the perceptual circumstances be before it is no longer right to count one as having seen something under those circumstances?

The answers to such questions as these[35] are, I suggest, more a matter of decision than discovery. Paradigmatic vision is of unobscured objects nearby and in front of our eyes, emanating or reflecting electromagnetic radiation within the visible range, whose

[35] There are many other such questions to ask, concerning the role of "top-down" perceptual processing, the degree of visual acuity, the extent of causal disconnection between perceiver and perceived required to classify a perceptual experience as hallucinatory rather than merely illusiory, and so on.

straight-line path from object to eye proceeds through nothing more disruptive than air, and reaching a subject who is wide awake and attentive, enjoys 20/20 vision, and a mind unclouded by drugs. Departures from these conditions in various respects and degrees are less obviously cases of (veridical) perception. If the departure is great enough, we will be unwilling to count the would-be perceiver as seeing the relevant object at all. But there is, I suggest, no respect or degree that makes for the difference above and beyond what we are collectively willing to count as doing so.

This is not to say that our decision is arbitrary. On the contrary, we are, I think, guided by fundamentally epistemic considerations. Mirror-images are worrisome because we might mistake the apparent location for the true one. Every additional transformation of the signal that reaches our senses introduces the possibility that the transformation degrades that signal. Two hairs on the tip of a dog's tail is a poor basis for reliable judgment as to the object's identity. And so on.

There are two dimensions to these epistemic considerations. The first concerns the reliability of the causal process that connects perceiver and perceived. This is the dimension captured in the "correlations" between systems X and Y in terms of which the pragmatic theory is exclusively characterized.

The second dimension concerns what I will call the "fidelity" of the perceptual experience. This concerns, roughly, the extent to which features of the scene which the perceiver seems to see (hear, etc.) are to be found, and suitably located, in the perceiver's physical environment. Fidelity of perception by means of a mirror is typically high, for example, excepting the disparity between perceived and true spatial location of the object

in view. [36] (That this is the only departure makes the automobile manufacturer's opinion understandable.)

The dimension of fidelity of perceptual experience is utterly absent from the pragmatic theory. As a matter of sheer correlation, there is no reason to privilege direct sight over mirror images; the correlation between perceived location and true location is just as tight in either case. But there is a reason to privilege direct sight; the perceiver, assuming that things are as they seem to be, will not be led astray in the one case but will be in the other.[37]

VII. Seeing Through Microscopes

In run-of-the-mill seeing, evolution has equipped the human body with a perceptual system that exploits information-bearing characteristics of the energy with which it is continuously bombarded. Evolution has also ensured that human beings find it natural to trust their perceptions (or are at least disposed to acquire that trust very quickly). We do not insist, *per impossible*, that the correlations between object and image be independently determined before we run from the perceived tiger. Creatures that

[36] The concept of perceptual fidelity, and of the perceiver's side of the perceptual transaction in general, needs much more elaboration than is presented here. I speak, for example, of similarities between object and image in a manner that smacks of representationalism, a position I nevertheless reject. But the issue is too complex to be dealt with adequately here. I pursue it in Alspector-Kelly 2002.

[37] Of course, the perceiver will not be led astray if she knows what mirrors do. But that is just to say that such familiarity informs her that how things seem perceptually—that someone stands directly in front of her, mimicking her behavior in every respect save reverse left-right orientation—is not really how they are.

distrustful of their perceptual experience will, after all, die very quickly, long before they have a chance to be frustrated by sceptical dilemmas.

Our perceptual system, in the right circumstances, is remarkably accurate and efficient; but it does have its limitations. Those limitations are, as van Fraassen points out, to be described in physics and biology (and, I suggested earlier, perceptual psychology). Some of those limitations can, however, be improved upon. Being in possession of a great deal of information about physics, optics, and perceptual processes, we have designed instruments that generate perceptual experiences which are reliably causally correlated with properties of the object at which the instrument is directed. Moreover, the fidelity of image to object is very high in a number of respects (though not, typically, all), so that one is in a position to learn much about the object by identifying the characteristics of what one seems to see.

The same is true of any successful perception enhancement technology, from corrective glasses, to mirrors, to hearing aids, to night-vision goggles, to the Hubble telescope to electron microscopes. The trust that we naturally place in naked-eye observation must be earned in these cases. But that is precisely what the relevant science behind these technologies makes possible: we know the respects and degrees to which imaging generated with electron microscopy, for example, is (and is not) faithful to the objects viewed because we know what the process is—complicated though it be—that brings the image from the object to our eyes. The "technology" involved in naked-eye vision is itself extremely complicated, after all, and we still have much to learn about it. The trust we place in naked-eye vision is innate, but we are still finding out why—and to what extent—that trust is well-placed.

Perceptual enhancement technology is not, of course, invariably faithful to the object imaged. Someone who has never yet heard of or encountered microscopes might well, upon their first view through the eyepiece, conclude that the object seen is considerably larger than it is; the greenish environment seen by means of night-vision goggles is in fact multi-colored; and so on. But neither, of course, is naked-eye observation invariably veridical. The moon is much larger and further away than our perception of it would suggest. And we do, as van Fraassen reminds us, seem to see nonexistent rainbows. The important thing is to know when what one seems to see is faithful to the subject-matter, and when it is in some way an artifact of the perceptual circumstances. This is no less important in unaided perception than it is in technologically enhanced perception. Perceptual experience is the source of information about the world; but it is not an infallible source, whether aided or not, and is subject to correction.

Many imaging technologies do involve transformations of the causal signal; the stream of electrons with which the sample is bombarded in an electron microscope, for example, must be converted to visible electromagnetic radiation. That is something to consider before granting that the electron microscope allows us to see the objects sampled. But it is not likely to delay us very long; the transformation is not so different from that involved in hearing aids, night-vision goggles and closed-circuit television (in fact, it involves fewer transformations than in these cases), and we know which characteristics of the object we seem to see correlate with the sample (and which do not).

In sum, perceptual enhancement technologies inevitably involve some departure from the causal route by which we typically come by our perceptual experience, as well

as some loss of fidelity in certain respects (though typically not much, and often with gains in other respects). This calls for a decision as to whether their use should be characterized as providing new ways to learn truths from the immediacy of perceptual experience. There is no further fact concerning what we really see and what we do not to be uncovered and to which these decisions are answerable. These decisions will be made, no doubt, in the organic and implicit manner in which decisions concerning the applicability of old concepts to new circumstances are always made by a linguistic community.

But the pattern of those decisions to date—admitting telephones, hearing aids, closed-circuit television, and a variety of other technologies as constituting new ways to see and hear the world—indicates that similarity to the old causal route does not matter very much. And even if it did, microscopy as a technological category does not inevitably involve greater departures from the biological norm than is represented by these accepted technologies.

What does matter, as it should—especially to the empiricist—is the epistemological value of the transaction, that is, the reliability of the causal process and fidelity of the perceptual experience that is its product. On these dimensions, there are many reasons to be impressed with the achievement represented by such technologies as the electron microscope, and so no reason not to construe it as a window on the microcosm. Van Fraassen's reluctance to extend the concept of seeing to beyond naked-eye vision is both epistemically unfounded and out of line with the conceptual decisions concerning when and what we see that have already been made, decisions whose epistemological ground should warm an empiricist's heart.

Remember that van Fraassen is not in a position to object that I am presupposing the science behind electron microscopy which speaks of electrons, belief in whose existence is part of what is at issue between the realist and the constructive empiricist. For we are still engaged here in the determination of what perceptual experience reveals about the world, and how it reveals it. That is a common task, one that realists and constructive empiricists (or at least some realists, against whom constructive empiricism is positioned) share, *before* they embark on their epistemological dispute concerning various portions of scientific doctrine. There are, of course, anti-realists who repudiate, or at least question, this naturalistic point of departure; but van Fraassen is not one of them.

Notice also that the claim that viewings through microscopes deserve to be treated as empirical sources of information does not depend on a Hacking-style common-cause argument. The electron microscope is a window on the microcosm because it generates reliable images in a manner that, while certainly not identical to the process involved in the generation of naked-eye images, is as reliable as that process. We know of that reliability in virtue of knowing the science behind it, just as the constructive empiricist knows the limits of unaided human observation by knowing the science behind the perceptual process.

Nor need all who enjoy the view through an electron microscope understand that process. If the question of its reliability comes up there are those who can explain it, in just the way that if the question concerning the reliability of naked-eye perception comes up, there are those who can describe that process. Remember that most of us, and most people who have lived to trust their senses, cannot do that.

Finally, notice that this is not the standard argument for the expansion of our epistemic community to include people (or aliens) with electron-microscope eyes. My suggestion is not that views through the electron microscope are not windows on the microcosm for most of us, but might be for those with a suitable genetic heritage, so that excluding such putative creatures from our epistemic community would be sheer anthropomorphic bigotry. It is instead that, given what it *is* for experience to provide us with information about the world, electron microscopes and the rest expand *our* community's ability to do precisely that, whatever wonders, genetic or otherwise, the future might bring.

Are there any entities that lie, in principle, beyond the reach of perceptual experience? I share Maxwell's reluctance to prejudge the issue, but we can identify the reasons why they would be. Perhaps it is physically impossible that we could stand in the requisite causal relations to them (because they lie outside of our light-cone, say). This would exclude tokens of certain types of entity (certain stars, for example), but there is no reason to think that it would exclude every member of any particular type. (We have, for example, no reason to think that there is a type of celestial body whose instances all lie outside of our light-cone). We would therefore not be in a position to express a form of scepticism (or agnosticism) as concerning the unobservable Xs where X is a name for a category of entity, which the constructive empiricist claims to be able to do.

Or perhaps some or even all of an entity's characteristics are simply too exotic to be perceptually representable. That is, perhaps there is no characteristic that something could perceptually seem to us to have that we could identify with the exotic characteristic possessed by the object, no matter what causal connections we might arrange between

ourselves and it. At least some quantum-mechanical properties might well be literally unimaginable (and unperceivable) in this way. But what is (imaginable and) perceptually representable might be a matter of both biology and education; who knows what we might not be able to so represent given suitable training? And we might, in the end, wonder whether we ought to leave perceptual fidelity behind and proceed solely with perceptual detectability. Perhaps, that is, the pragmatic theory was right after all, including its unintended (at least by van Fraassen) consequence that every successful experimental arrangement constitutes an extension of our experiential domain.

Whatever one might think of the rather dramatic extension of our perceptual reach just contemplated, even a relatively conservative estimation of the reach of our perceptual abilities, concerned with both reliability and fidelity, has them extending much farther into the microcosm than the overly conservative constructive empiricist is willing to recognize.

VII. Conclusion

There is, I conclude, no justification for the favoritism that van Fraassen extends to naked-eye observation to be gleaned from the epistemically relevant factors involved in perception. We do see the truth about many things in the immediacy of experience thanks to the perceptual technology with which evolution has equipped us. And thanks to more recent developments in the same field, we now see the truth about many more. We are therefore able to perceptually penetrate van Fraassen's second world; the charge that

we are limited to mere guesswork as to the success of our inferences concerning that world is simply false.

This is not to undermine the distinction between empirical evidence and hypothesis, or the significance of issues pertaining to the passage from the one to the other. But the distinction applies piecemeal in science and in ordinary life, and cannot be used to draw epistemically significant lines between general ontological domains.

Empiricism, according to which those empirical checks are our epistemic touchstones, thus stands in no conflict with realism concerning "unobservable" entities (insofar as this latter expression retrains any sense). It is strange that an empiricist would minimize, rather than celebrate, the expansion of our sensory contact with the world that technological innovation provides and the new epistemic possibilities it brings to us.

The position on perception sketched here, and so these consequences drawn from it, will not please all. But if the reader is not convinced on that matter, I hope that she can at least endorse the fundamental point, that a crucial issue underlying the debate engendered by van Fraassen's advocacy of constructive empiricism over the last twenty years has not been directly and adequately addressed. The limits of perceptual experience determine the separation (if any) between the domains accessible by observation and (if at all) by inference. The determination of those limits—how and to what extent experience delivers us information about the world—is therefore crucial if we are to determine what is at stake in the debate between the constructive empiricist and the realist.

References

Alspector-Kelly, 2001. “Should the Empiricist be a Constructive Empiricist?”, *Philosophy of Science* 68, 413-431.

Alspector-Kelly 2002. .Perception and Pretense: The Problem of Illusion and the Direct/Indirect Realism Debate.” Unpublished Manuscript.

Churchland, P. M. & Hooker, C. A. (eds.) 1985, *Images of Science: Essays on Realism and Empiricism* (Chicago: University of Chicago Press).

Churchland, P. M. “The Ontological Status of Observables: In Praise of the Superempirical Virtues,” in Churchland & Hooker 1985, 35-47.

Ellis, Brian, 1985, “What Science Aims to Do,” in Churchland & Hooker 1985, 48-74.

Foss, Jeff, 1984. “On Accepting van Fraassen’s Image of Science,” *Philosophy of Science* 51, 79-92.

Hacking, Ian 1983. *Representing and Intervening* (Cambridge: Cambridge University Press).

Hacking, Ian, 1985. “Do We See Through a Microscope?”, in Churchland & Hooker 1985, 132-152.

Maxwell, Grover, 1962. “The Ontological Status of Theoretical Entities,” *Minnesota Studies in the Philosophy of Science* vol. III, 3-27.

Musgrave, Alan, 1985. “Realism versus Constructive Empiricism,” in Churchland & Hooker 1985, 197-221.

Nagel, Jennifer, 2000. “The Empiricist Conception of Experience,” *Philosophy* 75, 345-376.

Schiffman, Harvey Richard, 1996. *Sensation and Perception: An Integrated Approach, Fourth Edition* (New York: John Wiley and Sons).

Seager, William, 1995. “Ground Truth and Virtual Reality: Hacking vs. van Fraassen,” *Philosophy of Science* 62, 451-477.

Sober, Elliot, 1993. “Epistemology for Empiricists,” *Midwest Studies in Phiulosophy XVIII,* 39-61.

Teller, Paul, 2001. “Whither Constructive Empiricism?”, *Philosophical Studies* 106, 123-150.

van Fraassen, Bas, 1980. *The Scientific Image* (Oxford: Oxford University Press).

van Fraassen, Bas, 1985. “Empiricism in the Philosophy of Science,” in Churchland and Hooker 1985, 245-308.

van Fraassen, Bas, 1992. “From Vicious Circle to Infinite Regress, and Back Again,” *Philosophy of Science Association Proceedings*1992 Vol. 2, 6-29.

van Fraaassen, Bas, 2001. “Constructive Empiricism Now,” *Philosophical Studies* 106 (1-2), 151-170.

Volmer, Sara, 2000, “Two Kinds of Observation: Why van Fraassen Was Right to Make a Distinction, but Made the Wrong One,” *Philosophy of Science* 67, 355-365.

Wilson, Mark, 1985, “What Can Theory Tell Us About Observation?”, in Churchland & Hooker 1985, 222-244.