

Chapter Six

EVIDENCE AND EXPLANATION: SOME QUESTIONS

The concept of explanation should not be monopolized by the philosophy of the natural sciences. The concept of explanation, like the concept of knowledge to which it is closely related, is an epistemic concept, and therefore has a philosophical location within the theory of knowledge, widely conceived. The philosophy of science has a great contribution to make to the theory of explanation, just as it does to a theory of knowledge, but it is not the sole proprietor of either concept.

David-Hillel Ruben¹

SOME PERSISTENT WORRIES

Most of the remainder of this book will be very hands on. I want to take the basic procedure which we began in Chapters Four and Five, and develop a procedure, what I have called a "recipe," for evaluating the quality of evidence presented in different kinds of arguments. Before returning to the Inference to the Best Explanation recipe, however, we need to pause and reflect on a couple of on-going debates in professional philosophy. I do this not just because I am a professional philosopher and enjoy these kinds of disputes, but also because so many of my students, often the best students, have raised many of the same worries that makeup much of the literature on IBE.

Inference to the best explanation has certainly had its advocates. One distinguished historian and philosopher of science has described it in the title of a book as *The Inference that Makes Science*.² Another sees it as ubiquitous in all of science.

One way to argue a theory is to show that it provides a good explanation of a body of phenomena and, indeed, that it provides a better explanation than does any available alternative theory. This pattern of argument is not bounded by time or by subject matter. One can find such arguments in sociology, in psychometrics, in chemistry astronomy, in the time of Copernicus and in the most recent scientific journals.³

At the same time, however, other equally distinguished philosophers of science categorically reject the theory.

There are many charges to be laid against the epistemological scheme of Inference to the Best Explanation. One is that it pretends to be something other than it is. Another is that it is supported by bad arguments. A third is that it conflicts with other forms of change of opinion, that we accept as rational.⁴

Clearly, my whole book takes sides on this controversy. I owe it to you to say a little bit about why I side with the champions of IBE.

TWO HUGE PROBLEMS FOR INFERENCE TO THE BEST EXPLANATION

Despite its intuitive plausibility, IBE faces two key challenges. First, how exactly is IBE to be understood and made precise? There are various conceptions of the nature of explanation, but assuming some of these are suitable for IBE this still leaves the question as to how one explanation should be compared against another so that the best explanation can be identified. Second, what is the connection between explanation and truth?

Is there any reason for thinking that the best explanation is likely to be true? Or to put it another way, does IBE track truth? Of course, no approach should be expected to lead to the truth in every instance, but if IBE is to be accepted as a rational mode of inference, there must be some reason for thinking that it provides a good strategy for determining the truth.

David H. Glass⁵

Many of the philosophical concerns about IBE stem from the very nature of evidence, or in the parlance of logicians, inductive arguments. Deductive certainty was the ideal, if not the realistic hope, of many earlier generations of methodologists. The sad fact is, however, is that evidence, even spectacularly good evidence, will never logically guarantee the truth. Even if every purported fact offered as evidence is conceded as true, and even if all rival explanations are ridiculously implausible, this will not prove (in the logician's, not the lawyer's, sense) that the theory being defended is true. We saw that already in the little bit of high school gossip concerning Connie. She has pretty strong evidence that he was smooching Mary Jane, but it's possible that there was the chemical reaction with the detergent residue, or that Mary Jane is more cunning and devious than anyone ever suspected.

We cannot expect evidence to guarantee truth, but it must surely "track" truth – that it supply "some reason for thinking that it provides a good strategy for determining the truth." I believe that explanation and evidence do supply a good strategy for determining truth, indeed I am tempted to say that it is the only strategy. I return to campus for the fall start of the academic year convocation. The first two people I see are my longtime colleague, Jill, just back from her year in South America, and my boss, Steve. Jill looks great; refreshed, and enthusiastic about returning to the trenches. Steve is a huge surprise, clean shaven and having lost a lot of weight. Surely I know that Jill and Steve are at the

convocation without the need of evidence; I need no strategy for determining the truth – it's manifest. But, of course, what I saw is really only evidence for the way things are. Jill and Steve being at the convocation are pretty darn good explanations of what my senses have told me. But ever since Descartes we have known that the senses sometimes lie. The rival explanation that it was not Steve, but the new hire in Accounting who bears an uncanny resemblance to Steve, and that it was Jill's twin sister is certainly possible, however unlikely.

So, then, how does IBE track truth? The answer, I am convinced, is illustrated in my knowledge that Steve and Jill were at the convocation. I saw them there! Yes, yes, skeptical doubts are possible, and on some definitions, I should have placed the word knowledge in scare quotes. But, in fact, we are all skillful practitioners at recognizing human faces, particularly those belonging to good friends and colleagues. In similar fashion Connie saw, not just the lipstick stain, but the whole sordid situation with her boyfriend and Mary Jane. Larry Wright articulates this point beautifully.

Virtually everyone who has survived past infancy has a more or less well developed set of perceptual skills. These skills may be generally described as the ability to *tell what's going on* (sometimes) simply by seeing it ... This ability to tell what's going on—or what's gone on—even when we are not confronting it directly. We can often tell what has happened from the traces it leaves. We can tell there was a frost by the damaged trees; we know it rained because the mountains are green; we can tell John had some trouble on the way home from the store by the rumpled fender and the broken headlight. We reconstruct the event from its telltale consequences. It is this diagnostic skill we exploit in the most basic sort of inductive arguments; it is the foundation of our ability to evaluate evidence.⁶

I suspect that the truth-tracking skill in determining what's going on is deeply biological. But whether its origins are evolutionary, a gift from a benevolent creator, or the product cultural teaching, I don't see how we can possibly doubt that normal human beings possess this skill.

The baby, assailed by eyes, ears, nose, skin, and entrails at once, feels it all as one great blooming, buzzing confusion; and to the very end of life, our location of all things in one space is due to the fact that the original extents or bignesses of all the sensations which came to our notice at once, coalesced together into one and the same space.⁷

Connie's visual system sent tens of millions of signals to her brain every second, and billions of neurons processed these signals. When describe at this level it tempting to suppose that she must have experienced, in William James' famous one-liner, "blooming buzzing confusion." We now know that this does not accurately describe even infant perception, but as James clearly saw over one hundred years ago it certainly does not capture Connie's experience. She does not experience millions upon millions of visual signals during the five minutes or so that puts things together, but rather sees shirt collars, lipstick stains, boyfriends, and soon to be ex, best friends. None of this is news. But it is still directly relevant. We should never forget how incredibly complicated, almost miraculous, perception really is.

All of that potentially blooming, buzzing confusion gets filtered, repackaged, abbreviated, and modeled in at least four different levels. One, of course, is the biological. We know a lot now about how the "simple" physics of optics, the physiology of the eyes, and the neuro-computational power of the human brain allowed Connie to see human beings, colors of lipstick, and the other objects that are the simple components of her narrative.

The human visual system sends ten million signals per second to the brain, where billions of neurons strip off random fluctuations and irrelevant, ambiguous information to reveal shape, color, texture, shading, surface reflections, roughness, and other features. As a result, human beings can look at a blurry, distorted, noisy pattern and instantly recognize a tomato plant, a car, or a sheep.⁸

The next level is one of conscious awareness. As her suspicion and anger grows, she loses awareness of what record is playing, or that her friend Annette looks slightly ill. Her auditory and visual systems are working just fine, but she doesn't hear the song, nor see the distress. Perception automatically focuses, which means sensory data is necessarily edited out. Add to this the fact that perceptual reality is clearly socially constructed. Connie doesn't see shapes, objects and motion, not even a young male and a young female, but a boyfriend and a best friend. She doesn't observe color patches on faces; she sees lipstick. And she doesn't "see" osculation, rather betrayal. Finally, when she records the day's events in her diary, she has to capture all of what she has seen in language.

The use I want to make of all this is rather mundane. Biologists, neuroscientists, psychologists, and sociologists have vital things to teach us about how perception works. But, however valuable all this research is, it is of virtually no use in teaching Connie to see. Perhaps she is particularly dense and doesn't see that her boyfriend is such a louse. She could be one of those sad individuals who fails to notice things. We see the lipstick on his collar, and Mary Jane's face when she reappears. How do we tell Connie to wake and smell the coffee? Imagine how absurd the following advice would be. "Connie, focus on those ten million signals, allow your billions of neurons to process them more carefully. Don't you see his is red but yours is baby pink?" The articulation of a theory of perception is entirely

independent of a recipe or instruction manual for more accurate seeing. We seek a description of perception, not a primer for perceiving.

I am not suggesting for an instant that we should leave perception, explanation, and causation as unanalyzed (perhaps unanalyzable) givens. We need to learn as much as we possibly can about component parts of inference to the best explanation. In addition, what we have discovered can be put to good use. My whole career as an educator has been committed to the belief that critical thinking skills can be taught and nurtured. Normal humans are already amazingly skilled perceivers, and I believe explainers. But they can learn to be even more skilled. Tricks, tips, but also lots of hard work and experience can improve all of our perceptual abilities. What I am insisting on, however, is that all of our best scholarship on perception and explanation will focus much more on describing a skill that humans already possess, and have only limited utility as a formula for how to perceive, or how to explain.

EXPLANATORY VIRTUE

Let's return to Glass's first worry about IBE – "how one explanation should be compared against another so that the best explanation can be identified?" Philosophers have had a great deal to say about this. Consider the thoughts of Thomas Kuhn.

These five characteristics—accuracy, consistency, scope, simplicity, and fruitfulness—are all standard criteria for evaluating the adequacy of a theory. ... [T]hey all play a vital role when scientists must choose between an established theory and an upstart competitor. Together with others of much the same sort, they provide *the* shared basis for theory choice. ... Even those who have followed me this far will want to know how a value-based enterprise of the sort I have described can

develop as a science does, repeatedly producing powerful new techniques for prediction and control. To that question, unfortunately, I have no answer at all.⁹

Connie's new best friend, Sarah, listens to her sad story, and concludes that Connie's evidence is pretty strong. Since Sarah has made a judgment about the quality of the evidence, according to IBE she has implicitly ranked the alternative explanations by some scale or standard.

- t₀. The smooching hypothesis
- t₁. The laundry detergent hypothesis
- t₂. The revenge hypothesis

Why is t₀ significantly better than t₁ or t₂? The answer is implicit in the earlier answer to why and how IBE tracks the truth. Since we are dealing with a human cognitive/perceptual skill, the challenge is to articulate how this skill works.

How do we judge that any explanation counts as better than any other explanation? Harman counsels simplicity, completeness and plausibility. Kuhn favors accuracy, consistency, scope, simplicity, and fruitfulness. Wright talks of explanations comports with the data and seeks "fit."

[T]he only very general thing we can say about what we do when we evaluate evidence is rather coarse-grained. When we do prefer one member of the list of rivals to the others, we do so simply because it comports best with the data we have, against the background of our relevant knowledge. Some rivals score better in some ways, others in others. We weigh the tugs in all directions and judge one rival to 'fit' better than the others, all things considered. ... So at bottom it is always a complex judgment of fit: which one fits most easily with everything we know about the matter.¹⁰

Achenstein demands quasi-mathematical precision.

[E]vidence e must be a good reason to believe h e is such a reason only if the probability of h , given e , is sufficiently high ... that is e is evidence that h if and only if $p(h/e) > k$, where k is some threshold value for "sufficiently high." ... If k were less than one-half, since incompatible hypotheses can both have probabilities less than one-half, it would be possible for some e to be evidence for each of two incompatible hypotheses ... [t]herefore we may conclude that e is evidence that h only if $p(h/e) > 1/2$ Another way to put this is e is evidence that h only if h is more probable on e than its denial on e : $p(h/e) > p(-h/e)$.¹¹

And Peter Lipton famously eschews probabilistic criteria, and insists on an aesthetic virtue.

[T]he version of Inference to the Best Explanation we should consider is Inference to the Loveliest Potential Explanation. Here at least we have an attempt to account for epistemic value in terms of explanatory virtue. This version claims that the explanation that would, if true, provide the deepest understanding is the explanation that is likeliest to be true.¹²

Most of the literature treats such proposed criteria for judging explanatory virtue as though they were competing accounts. The players themselves often contribute to this view. Now, if what is being offered is an analysis, or definition, of the best explanation, they most certainly are incompatible pictures. I will offer a very different interpretation in the next section, but I cannot resist a pedagogical comment at this point.

Whatever is going on, I ask you to imagine teaching your classmates, or instructing a jury, based on either Achenstein's or Lipton's criteria. If Connie is anything like a good portion of my students, asking her to rank order the lipstick hypotheses on the basis of statistics and the probability calculus will be a laughable failure. And to ask

the blue-collar worker on the jury to assess preponderance of evidence, or proof beyond a reasonable doubt, on the basis of the loveliest potential explanation will have an equally disappointing end. Wright and Harman may prove more pedagogically useful, but I suspect that has more to do with their more colloquial language, and the fact that their criteria are more general and vague.

TACIT KNOWLEDGE AND EXPLANATORY VIRTUE

In a wonderful movie about globalization and the French Bordeaux industry, *Red Obsession*, the wine critic, Michael Bettane describes how he identifies a world class Bordeaux.

As soon as you have to use words to describe your sensation, you use words in a part of your brain which is linked to your memory, to your history, to your taste, to your education. In my brain, because it's my background, is music. This is like a voice, a wine, it's like an instrument with what we call a timbre, which is different – a Steinway is not the same, and that's the difference between Lafite and Latour, between a Guarnerius and a Stradivarius . My perception is like that. I hear the wine, I don't smell. heh, heh.¹³

It should come as no surprise that I think both of David Glass's challenges to IBE have a single answer. I have already argued that IBE often successfully tracks truth because humans possess a perceptual skill at "seeing" the truth. This perceptual ability includes the ability to, not only see the truth, but to see why and how one hypothesis is better than another, and way, way better than yet a third. I realize that this will strike some readers as an appeal to mystery, and to some degree that's exactly what it is. But I remain unapologetic, since much of human perceptual skill is even more mysterious. Consider hitting a major league fastball.

A typical major league fastball travels about 10 feet in just the 75 milliseconds that it takes for sensory cells in the retina to confirm that a baseball is in view and for information about the flight path and velocity of the ball to be relayed to the brain. The entire flight of the baseball from the pitcher's hand to the plate takes just 400 milliseconds. And because it takes half that time merely to initiate muscular action, a major league batter has to know where he is swinging shortly after the ball leaves the pitcher's hand -- well before it's even halfway to the plate.

The window for actually making contact with the ball, when it is in reach of the bat, is five milliseconds, and because the angle of the ball relative to the hitter's eye changes so rapidly as the ball gets closer to the plate, the advice to "keep your eye on the ball" is impossible to follow. Humans don't have a visual system fast enough to track the ball all the way in. A batter could just as well close his eyes once the ball is halfway to home plate. Given the speed of the pitch and the limitations of our physiology, it seems to be a miracle that anybody hits the ball at all.¹⁴

But, major league hitters not only succeed in making ball to bat contact, they manage to successfully get base hits somewhere between a quarter and a third of the time. How the heck are they able to do that? To continue with the theme of the last few sections, it is fascinating to more carefully explore a perceptual skill like hitting a fastball, but trusting hitters to describe the skill, or worse, taking these descriptions as instruction manuals for becoming a good hitter, is not only misleading, but downright counterproductive.

I hear Michael Bettane as not smugly announcing a superior way of discerning a great wine, but as somewhat embarrassed at offering a ridiculous and unhelpful account of how he does it. I think it is useful to see the suggested criteria for explanatory virtue in a similar light, not embarrassed of course, but as idiosyncratic attempts to

articulate something deeply perceptual. Those comfortable with numbers will find Achinstein's statistical criteria insightful, and even useful. Those who are more at home with spatial and physical metaphors are more likely to be drawn to Wright's discussion of tugs and fits. I take them all to be sincere and good willed attempts to articulate something that most humans are very good at, and some humans like natural scientists are exceptionally good at. But as anyone who has ever tried to hit a fastball, or teach someone to hit one, can tell you, it's easier to do it, than to put it in words how you do it.

THE BAD LOT PROBLEM

You will recall that Bas van Fraassen is one of IBE's most sustained and sophisticated critics. Here's is perhaps his most serious argument against it.

Inference to the Best Explanation[']s] ... purport is to be a rule to form warranted new beliefs on the basis of evidence, the evidence alone, in a purely objective manner. It purports to do this on the basis of an evaluation of hypotheses with respect to how well they explain the evidence, where explanation is again an objective relationship between hypothesis and evidence alone.

It cannot be *that* for it is a rule that only selects the best among the historically given hypotheses. We can watch no contest of the theories we have painfully struggled to formulate, with those no one has proposed. So our selection may well be the best of a bad lot.¹⁵

A detailed response to the best of a bad lot argument will give me an opportunity to reiterate and expand on my perceptual skill defense of IBE. Let me begin by questioning the claim that IBE "only selects among the historically given hypotheses." Samir Okasha concedes much to van Fraassen on this score.

Clearly van Frassen is right that if we are trying to rank a set of hypotheses according to how well they explain our data, only hypotheses we have actually thought of will be in the ranking—that much is virtually tautological. And clearly he is right that, if IBE is a rule that tells us to believe the best explanation of our data, rational application of IBE requires a prior belief that the truth lies within the set of hypotheses we rank.¹⁶

There are two responses to this claim, responses that at first glance seem to contradict one another.

It is far from clear that “only hypotheses we have actually thought of will be in the ranking.” Or, better, we often include a default explanation – ***none of the above*** or ***something else we haven't thought of*** – unstated, but implicitly included in our ranking. In the famous case of Semmelweis that we will be looking at directly, before the accident with his colleague, he had no best explanation of childbed fever, but he was confident in ranking the existing candidates – miasma, rough handling by interns, *etc.* – very low. We often see this in the early stages of an inquiry, be it science, auto repair, or homicide investigation. We're not at all sure what's going on, but still pretty confident about what's not going on. Once we include the default explanation of current ignorance in our list, the bad lot immediately becomes a very strong lot.

But I will concede that there are times when we do focus on what we know is a bad lot. The Lieutenant calls the squad together and announces, “we have no evidence that Smith or Jones are involved, so we'll take the stakeout off them and concentrate our efforts on Brown and Green, since we have at least some evidence they may have had something to do with it.” All of the explanations of the crime – Smith did it, Brown did it, Jones and Green working together did it – may have serious explanatory flaws, but we may still be confident in ranking one hypothesis as better

than another, and consequently making some judgment about evidential quality.

Here I am endorsing what Achenstein calls the "*Weakness Assumption*: Evidence is a weak notion. You don't need to have very much to have evidence for a hypothesis."¹⁷ He favors a threshold standard as we saw above, "*e* is evidence that *h* only if $p(h/e) > 1/2$." This high standard for evidence may well be important, at least for those comfortable with utilizing the probability calculus in their rank ordering. It could, for instance, tell us something interesting about the lawyer's notion of the preponderance of evidence. It might be what we insist on for confident judgments of **strong** evidence. But we make other evidential judgments as well. We talk about "preliminary evidence," "some evidence," and even "very weak evidence," and these notions may well rank stated hypotheses that we already concede are a bad lot.

Okasha wonders if van Frassen's IBE rule "tells us to believe the best explanation of our data," or as stated in the original, is "a rule to form warranted new beliefs on the basis of evidence." This goes back to the canonical version of IBE. From Harman:

In making this inference one infers, from the fact that a certain hypothesis would explain the evidence, to **the truth** of that hypothesis.¹⁸

Or Peirce, by way of Hanson:

The form of the inference is this:

1. Some surprising phenomenon *P* is observed.
2. *P* would be explicable as a matter of course if *H* were true.
3. Hence there is reason to think that *H is true*.¹⁹

This is certainly the ideal, but it may overstate some contexts in which evidence is both clear and useful.

When van Frassen first presented the bad lot argument, he suggested three possible responses, all of which he ultimately rejected.

The first consists in the claim of privilege for our genius. Its idea is to glory in the belief that we are by nature predisposed to hit on the right range of hypotheses. ... The *second* reaction pleads *force majeure*: it is to try and provide arguments to the effect that we *must* choose among the historically given significant hypotheses. ... The *third* reaction is to retrench: 'Inference to the Best Explanation' was a misnomer, and the rule properly understood leads to a revision of judgment much more modest than inference to the truth of the favored hypothesis. ... Despite its name, it is not a rule to infer the truth of the best available evidence. That is only code for the real rule, which is to allocate our personal probabilities with due respect to explanation. Explanatory power is a mark of truth, not infallible, but a characteristic symptom.²⁰

I absolutely sanction the validity of *force majeure*, since it is clearly the situation in which investigators from Semmelweis to Colombo find themselves as a daily and professional reality. If your job is to do something, or find something out, you darn well better use the best available evidence you have. My whole argument so far has been an implicit endorsement of privilege, and I will return to it in the next section. But, here, I think retrenchment is in order. Not that I see this as real retrenchment, since I have never seen IBE as a magic bullet to the truth, but rather as a standard of evidence that points us to the truth. Again, finding the truth is the ideal, but the facts that make up the evidence don't always lead us to new (true) facts, but possible facts. Sometimes evidence commands belief, but other times it only councils further thought, reflection, and investigation.

IS THE HISTORY OF SCIENCE A PROBLEM?

I agree with van Frassen that privilege is an extremely difficult position to defend, if only because the number of time scientists have failed to 'hit on the right range of hypotheses' in the past. If there is an innate predisposition to guess the truth, it is not one that manifests itself very often.²¹

My argument of course has bought, hook, line, and sinker, into an innate predisposition, I would call it an innate perceptual/cognitive skill, to do much more than guess the truth, but in many cases to actually "see" it. Most critics of IBE, and even some supporters, have worried that the history of science stands as a glaring counterexample to such an alleged skill.

[I]f you look at the success of theories historically, using any criteria of goodness, including "loveliness," the induction will be pessimistic. Indeed, even Whewell's two favorite theories (Newtonian gravitation, and the wave theory of light) turned out to be false, despite the fact that, according to him, they completely satisfied the requirements of consilience and coherence.²²

Newtonian gravitation turned out to be false, yet his discovery and defense can be reconstructed as a case study of IBE.²³ So it is fair to ask if the history of science doesn't provide data that is actually very poorly explained by my claimed cognitive skill.

Historians and philosophers of science are among the few methodologists who have taken IBE seriously. This is partly because so many historical examples – Lavoisier, Newton, Darwin, Wegener, to name just a few – fit the model so beautifully. But science may actually be a poor place to look for the triumphs of explanatory reasoning. For one thing, the sorts of grand scientific theories that are

usually investigated are just that, grand theories – general, abstract, and often composed of technical and theory-dependant concepts. Connie's skill at seeing what was going on with that conspicuous lipstick stain was likely inherited from her hunter-gatherer ancestors. Those skills transfer in very productive ways to what Kuhn called normal science. We are very good at seeing what's going on, i.e., explaining our results, in controlled laboratory experiments. Our perceptual ability remains useful in the "context of discovery" of sweeping revolutionary theories, as well, and the "context of justification" for defending these theories. But as these theories become more general, they also become more vulnerable. I remain in awe of the genius that could so spectacularly unite and explain Galileo's law of free fall and Kepler's laws of planetary motion. I see it as no indictment of Newton's perceptual skills that he was unable to foresee, both because of his paradigm, but also because of the then current state of knowledge, the discovery of fields, and ultimately the new paradigm of relativity.

Evidence and evidence evaluation are time dependent snapshots. They tell us how things stand at a particular time and in a particular context. The addition of new surprising observations, or the addition of new facts, constitutes a new argument. Sometimes this new evidence changes everything, as the case of Semmelweis's colleague's death famously showed. Sometimes the new evidence makes an existing argument even stronger, as did the results of Semmelweis's order to staff to disinfect illustrates. But in either case, we are dealing with a new evidential case. Newton's evidence did not transform from strong, to weak, because of the discovery of fields, and Einstein's relativity revolution. His evidence remained strong as it stood, but left things out that he could not have known. When these things are added the theory of Newtonian gravity is no longer the best explanation of everything we know. IBE gives us the tools to see why Newton's evidence was extremely strong in

his time, but also for seeing why current evidence no longer supports his theory.

ENDNOTES

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- ¹ David-Hillel Ruben, editor, *Explanation* (Oxford: Oxford University Press, 1992) p. 1.
- ² Ernan McMullin, *The Inference that Makes Science* (Milwaukee: Marquette University Press, 1992).
- ³ Clark Glymour, "Explanation and Realism," in Jarret Leplin, editor, *Scientific Realism* (Berkeley: University of California Press, 1984), p. 173.
- ⁴ Bas van Fraassen, *Laws and Symmetry* (Oxford: Oxford University Press, 1989), p. 142.
- ⁵ David H. Glass, "Inference to the Best Explanation: Does It Track Truth?" *Synthese* Vol. 185, No. 3 (2012), p.412.
- ⁶ Larry Wright, *Better Reasoning* (New York: Holt, Rinehart and Winston, 1982), p. 51.
- ⁷ William James, *Principles of Psychology* (Cambridge, MA: Harvard University Press, 1983). p. 462
- ⁸ Sharon Bertsch McGayne, *The Theory That Would Not Die* (New Haven: Yale University Press, 2012), p. 240.
- ⁹ Thomas Kuhn, *The Essential Tension* (Chicago: Chicago University Press, 1977), pp. 322-32
- ¹⁰ Larry Wright, "Induction and Explanation," *Philosophical Inquiry*, 41, 1982, p. 6.
- ¹¹ Peter Achenstein, *Evidence and Method* (Oxford: Oxford University Press, 2013), pp, 25-6.
- ¹² Peter Lipton, *Inference to the Best Explanation* (London: Routledge, 1991), p. 63.
- ¹³ Michael Bettane, wine critic and author. Interviewed in *Red Obsession*. Dir.
- ¹⁴ <http://sportsillustrated.cnn.com/more/news/20130724/the-sports-gene-excerpt/#ixzz2jhL229NL>
- ¹⁵ Bas van Frassen, *Laws and Symmetry* (Oxford: Clarendon Press, 1989), pp. 142-3.
- ¹⁶ Samir Okasha, "Van Frassen's Critique of Inference to the Best Explanation," *Studies in History and Philosophy of Science Part A* 31 (4):691-710 (2000), p. 694.
- ¹⁷ Achenstein, *op. cit.*, p. 10.
- ¹⁸ Harman, *op. cit.* My emphasis.
- ¹⁹ Hanson, *op. cit.* My emphasis.
- ²⁰ van Frassen, *op. cit.*, pp. 143-6.
- ²¹ Okasha, *op. cit.*, p. 696.

²² Achenstein, *op. cit.*, p. 106.

²³ See, Paul Thagard, *Conceptual Revolutions* (Princeton: Princeton University Press, 1992), p. 202.