A Defense for Scientific Realism:

Skepticisms, Unobservables, & Inference to the Best Explanation

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Abstract

The epistemological status of scientific knowledge claims has been undermined by skepticism, in particular by universal skepticism. This thesis asserts that Bas C. van Fraassen's empirical stance is akin to universal skepticism. This work also maintains that van Fraassen's empirical stance does not lead to the conclusion that scientific knowledge claims are empirically adequate—especially those claims that resulted from the scientific method of inference to the best explanation (IBE). To illustrate why van Fraassen's stance does not devalue scientific knowledge claims will be suggested via Peter Lipton's understanding of IBE combined with Ernan McMullin's epistemic values. By bridging McMullin's values with Lipton's version of IBE, we get a more robust version of IBE; as a result, scientific claims may display a cluster of epistemic virtues and values. Where scientific knowledge claims display a cluster of epistemic virtues and values, they are simply beyond being empirically adequate.

Contents

Introduction

It must be acknowledged first that this work is written in the same spirit as that of Peter Lipton, as advanced in his book titled *Inference to the Best Explanation*. This spirit is his acknowledgement that his work on inference to the best explanation (IBE) is not complete and his view is not infallible—he also makes a conscious effort not to use the "rhetoric of certainty" when describing his position.[1] Nonetheless, Lipton does believe his work has something valuable to say about the nature of science. Turning our attention to this current work, the tone set herein may suggest a language of certainty on the topic of how inference to the best explanation can be used to overcome universal skepticism, but this is not the case. What this work advocates is that inference to the best explanation is a good method on how to overcome universal skepticism. Moreover, there is one other assumption at play within this work, i.e., scientific conclusions reached via the method of inference to the best explanation can be rationalized at least as approximately true.[2]

The topic of this work is to briefly outline how universal skepticism has been used to discredit scientific knowledge claims, and in particular those claims that pertain to theoretical entities known as *unobservables*. To bring this to light, this discussion will focus on Peter Lipton's and Bas C. van Fraassen's arguments in support of and opposition to the scientific method of inference to the best explanation and the nature of scientific explanations—later on we shall see why the method of inference to the best explanation is the preferred method to advance the existence of scientific unobservables. The task of this work is to illustrate why van Fraassen's arguments against the

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[1] Peter Lipton, *Inference to the Best Explanation*: Second Edition (New York: Routledge, 2004), 4.

[2] There is much philosophical debate on what constitutes as approximate truth: Approximate is described in this work as: "it can be said that it satisfies the following platitude: for any statement 'p', 'p' is approximately true iff approximately p. This platitude shifts the burden of understanding 'approximate truth' to understanding approximation." Stathis Psillos, *Philosophy of Science A–Z* (New York: Edinburgh University Press Ltd., 2007) 12–13.

existence of unobservables are problematic—this is due to his position being akin to universal skepticism (although he claims he is not a skeptic of any sort). Later on, arguments as to why inference to the best explanation serves as justification for the existence of unobservables will be explored. In addition, it will also be argued that inference to the best explanation can be envisaged as a kind of methodological skepticism.

The method used to bring about what has been said is as follows: Chapter 1 will elucidate the concept of universal skepticism. Chapter 2 will briefly discuss whether or not it is rational to posit the existence of unobservables. Chapter 3 will discuss the pros and cons of scientific explanations and the scientific method of inference to the best explanation as per the works of Bas C. van Fraassen and Peter Lipton. Chapter 4 will discuss the justification for the epistemological standing of scientific explanations/hypotheses reached via the method of IBE.[3] Finally, Chapter 5 will discuss the practicality of IBE and how it can be envisaged as methodological skepticism. (This chapter will also include overall conclusions and implications of this work.)

Now that we established what this work entails, it is important to define some of the concepts that will be reoccurring throughout. *Universal skepticism* is understood as the view that nothing can be known. Methodological skepticism is usually associated with Cartesian skepticism, as Descartes methodologically sought to doubt all his beliefs. However, methodological skepticism, as defined here, doubts the truth of scientific explanations based on their lack of epistemic virtue when contrasted with other competing explanations for the same phenomena. Inference to the best explanation is part of the scientific method, which includes abduction, inductive, and deductive reasoning. It also includes the idea that scientific hypotheses are true based on evidence *beyond a reasonable doubt* (not beyond *all possible doubt*).

[3] The word hypothesis and explanation will be used synonymously throughout this work.

In sum, this thesis puts forth an argument for the conclusion that the method of inference to the best explanation not only gives us a means to justify why we may believe certain scientific hypotheses/explanations are approximately true, but it also gives a way to be proper skeptics. Furthermore, inference to the best explanation can be envisioned as a general method of how to evaluate and justify general knowledge claims.

Chapter 1

Universal Skepticism

> *"Of all things the measure is man: of existing things, that they exist; of non-existing things, that they do not exist."*
>
> Protagoras[4]

The purpose of this chapter is to define the term universal skepticism and to how it has been used to devalue scientific knowledge claims (in particular about unobservables).[5] Universal skepticism is defined in this work as an attitude, position, or belief that insists human knowledge cannot be obtained, and if it is obtained it will most definitely be questionable. To bring out this understanding of universal skepticism, the philosophical positions of Sextus Empiricus and David Hume will be discussed. A line will also be drawn to illustrate how Bas C. van Fraassen's empirical stance closely resembles universal skepticism.

Sextus Empiricus' skepticism is commonly known as *Pyrrhonian skepticism*. What makes Pyrrhonian skepticism unique is that its adherents do not assent to know something is or is not the case. The Pyrrhonian illustrates this point by maintaining that there are many equally good explanations to account for any one particular observable phenomenon.[6] Moreover, due to this equipollence that exists among explanations, the Pyrrhonian suggests that choosing any one

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[4] Protagoras, *On Truth*: John Manley Robertson, *An Introduction to Early Greek Philosophy* (Houghton Mifflin Co.,) 245.
[5] Unobservables are scientific entities that cannot be seen with the naked eye. More will be said about unobservables in this chapter and chapter 2.
[6]Sextus Empiricus Ibid., 5 (*PH* I 10).

particular explanation over another can be difficult and induce anxiety in the person who must choose an explanation. The Pyrrhonian's solution for removing anxiety is to suspend judgment (*epoché*). Epoché is achieved by not choosing any sort of explanation. The sole purpose of Pyrrhonian skepticism is to achieve tranquillity or peace of mind (*ataraxia*) through suspending judgement.[7] Pyrrhonian skeptics achieve ataraxia by not assenting to know or not know the hidden causes or forces that are responsible for any particular appearance. In conclusion, Pyrrhonian skepticism is a logically consistent position, as they do not assert to know the truth or falsity of any explanation or position. The Pyrrhonian is simply content to voice what they think appears to be the case.

On another note, if we are to adopt the Pyrrhonian point of view, we cannot give any account of unobservables seeing that would suggest that we assent to some criterion of knowledge, e.g., for the Pyrrhonian, any assertion that suggests the language of certainty presupposes that one accepts some criterion of knowledge. But if we were to restrict our explanations only to observable phenomena they would lack epistemological significance seeing that epistemological claims would be stated as more of an opinion versus a fact, e.g., "it appears to me that this is or is not the case." Nonetheless, Pyrrhonianism is a coherent position, even though it cannot be maintained in practise, as that would suggest one could truly suspend their judgment on all matters.

Hume was skeptical that the human mind could determine the truth of abstract concepts (which extended beyond quantity and number) because they lack the virtue of experimentation and experience. For Hume, knowledge derives from the mind's propensity to see patterns and regularities, via the senses, through cause and effects in nature—Hume refers to such knowledge as "matters of fact." Moreover, Hume also argued that our inferences, from cause and effect, might not necessarily be true or hold true in the future, e.g., we have no justified belief that the sun will rise

[7]Ibid., (*PH* I 18).

tomorrow, as the sun may not actually rise seeing that there may be numerous causes that may stop the sun from actually rising.[8] However, Hume does believe skepticism has an important role in the evaluation of knowledge, i.e., to help one see if they have become dogmatic in their view.[9]

This now takes us to Bas C. van Fraassen's *empirical stance*. Van Fraassen's empirical stance resembles universal skepticism, and also Pyrrhonian skepticism, because he denies there is any justification for knowledge claims that go beyond what is empirically verifiable or empirically visible.[10] This is van Fraassen's direct skepticism towards unobservables; however, van Fraassen has a larger criticism against scientific knowledge claims which also renders unobservables suspect beyond what has just been mentioned. The larger criticism is against the scientific method of Inference to the best explanation which is used to justify unobservables.

Van Fraassen has many arguments as to why the method of IBE can only render scientific facts as empirically adequate versus true. Only three of his arguments will be investigated in this chapter.[11] The first argument maintains that science is in the business of asking "why" questions. More specifically, the why questions scientists ask assume a tacit criterion of truth which predetermines the type of why questions scientists choose to investigate. Moreover, the answers to

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[8] There are two interpretations of Hume. The interpretation discussed above is referred to as the old Hume seeing that some scholars insists that he is an epistemic skeptic, i.e., Hume maintains nothing can be known of external objects, unobservables, and of cause and effect. Under the new interpretation of Hume he is understood as skeptical realist—this reading of Hume suggests that he is not skeptical of cause and effect, or for the existence of external objects. Rather, he is skeptical that the human mind can comprehend the nature of objects and cause and effect beyond how they are presented to our minds via our senses. Under the new interpretation of Hume, we can believe in case and effect and the external world, but only as it is presented to us and not beyond our senses and mental faculties. For more on this point see Galen Strawson in: *The New Hume Debate,* Rupert Read & Kenneth A. Richman (Routhledge London & New York, 2007) 35–38.

[9] Hume sees utility in skepticism: "There is, indeed, a more mitigated scepticism or academical philosophy, which may be both durable and useful, and which may, in part, be the result of this Pyrrhonianism, or excessive scepticism, its undistinguished doubt, are, in some measure, corrected by common sense and reflection. The greater part of mankind are naturally apt to be affirmative and dogmatical in their opinion; and while they see objects only on one side, and have no idea of any counter poising argument, they throw themselves precipitately into the principles, to which they are inclined; nor have they any indulgence for those who entertain opposite sentiments." David Hume, *An Enquiry Concerning Human Understanding*, 145–146.

[10]For van Fraassen, an unobservable is anything that cannot be empirically verified by one's senses and does not lend itself to direct experience. However, he has softened his view on this distinction over the years. For this thesis, unobservables will be understood as van Fraassen originally outlined in his *Scientific Image*.

[11] There is no need to go into all of the details of van Fraassen's critiques against IBE and the unobservable at this time, as they will be thoroughly addressed in chapter 3 and 4.

these why questions may be limited to scientific enquiry and investigation; as a result, the why questions scientists choose to answer may be biased and incorrect for explaining why a particular phenomenon occurs.[12] The point is that, if scientific-type questions are preferred over unscientific ones, it rules out the possibility for unscientific answers to compete in explaining phenomena. To conclude, unscientific answers may be best to explain some phenomena; however, if only scientific-type questions are asked, it removes the possibility to have unscientific explanations to elucidate phenomena. (For van Fraassen, unscientific explanations are those explanations that are not justified or informed by scientific methodology and principles.)[13]

The second argument is that for any given hypothesis we believe is true, we implicitly accept its evidence and other supporting hypotheses are also true. In other words, scientific hypotheses are not generated in a vacuum—they are generated from evidence and the logical entailments of prior hypotheses. In sum, if the evidence, which supports a given lot of hypotheses, is not contested, that entire lot of hypotheses may be wrong. This point ties into the first argument; for example, if unscientific questions are not asked, then there are no unscientific explanations to compete in explaining phenomena. In conclusion, van Fraassen is skeptical of the accepted, and competing, lot of hypotheses because they may be the result of biased why questions. His point, then, is that we should be open to looking for unscientific explanations to elucidate phenomena, but this can only start with asking non-biased why questions. In addition, if we do not consider unscientific explanations for phenomena, we are limiting our pool of explanations (more on this point will be said in chapter 3).

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[12] Bas C. van Fraassen, "The Pragmatics of Explanation" (*American Philosophical Quarterly,* Vol. 14, No. 2 (Apr., 1977) 149–150.

[13] Van Fraassen does not explicitly give us a precise definition of unscientific explanations in his *The Empirical Stance*, but he does suggest that these explanations are not informed by scientific methodology and principles. Bas C. van Fraassen, *The Empirical Stance* (New Haven & London: Yale University Press: 2002), 15.

The third argument is a more direct criticism of IBE since it attacks the epistemic virtues, which are reasons to accept certain scientific hypotheses/explanations are true.[14] Van Fraassen argues that epistemic virtues within the scientific method of IBE cannot be used to justify scientific explanations seeing that they are not quantifiable terms.[15] (This point will also be revisited and made more explicit in chapter 3.) If the evidence that scientists use to justify why they believe hypotheses to be true is indefinable, it will render all scientific hypotheses suspect. To put it differently, if the criteria used to illustrate the probability of scientific hypotheses are true cannot be properly defined, then there is no justification for believing scientific hypotheses are true. Van Fraassen's answer to the above problem is quite simple: When scientists claim they believe a particular hypothesis is true, what they are actually doing is voicing their view (or stance) about that particular hypothesis.

Van Fraassen's arguments lead to two conclusions, and we will now see how these two conclusions are closely connected. Given the discussion in arguments one and two, scientists do not give good reasons to believe their hypotheses are true; at best, scientific hypotheses or explanations are only empirically adequate. Empirical adequacy simply asserts: The acceptance of a theory involves the belief that it makes accurate predictions about observables while denying any truth claims the theory implicitly, or explicitly, makes about unobservables. Leaving aside the point made about unobservables for chapter 2, science ignores unscientific explanations to explain phenomena; as a result, scientific explanations may not necessarily be true because they ignore other possible unscientific explanations to account for phenomena. According to van Fraassen, scientific explanations are only empirically adequate.

The second conclusion is found in van Fraassen's book titled *The Empirical Stance*. Van Fraassen claims that no scientific explanation is better than another seeing that we cannot properly define what constitutes as explanatory support for scientific explanations, i.e., the explanatory

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[14] This point about the epistemic virtues will be made clearer in chapter 3 & 4.

[15] van Fraassen, *The Empirical Stance*, 15.

virtues. In sum, if the evidence that is used to rationalize the truth or the probability of an explanation being true cannot be defined, it renders the explanation suspect. Moreover, it does not only render the explanation suspect, it suggests the explanation is more of a stance than a true explanation. For, if scientific explanations are only stances, then which stance is the better stance? According to van Fraassen, no stance is better than another. What we get is a "difference in attitudes toward the proposed or advocated theory."[16]

In conclusion, *empirical adequacy* and the *empirical stance* devalue the epistemological standing of scientific knowledge by illustrating that there is no concrete and rational means to accept scientific explanations as true beyond what they empirically describe.

The purpose of this chapter is to elucidate the concept of universal skepticism. Universal skepticism, as described here, is the view that nothing can be known, and this was elucidated via the works of Sextus Empiricus and David Hume. To conclude, universal skepticism denies not only scientific knowledge to be out of reach but knowledge of unobservables as well.

[16] van Fraassen, *The Empirical Stance*, 48–49.

Chapter 2

Scientific Realism: Are Unobservables Real?

> *"I understand scientific realism to be the view that theoretical statements of science are, or purport to be, true generalized descriptions of reality."*
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> Brian Ellis[17]

> *"Science aims to give us theories which are empirically adequate; and acceptance of a theory involves as belief only that it is empirically adequate."*
>
> Bas C. van Fraassen[18]

One of the questions asked within the philosophy of science, pertaining to unobservables, is whether they are real or not real. There are three prominent answers to the above. The first is that it does not matter whether or not unobservables exist, we treat them as if they do exist because they are useful theoretical constructs that can help enrich scientific explanations. The second answer is that it is difficult to say that unobservables exist, as there are no concrete means to show their influence within a causal chain of effects. Third and finally, some scientists suggest that unobservables can be real entities.

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[17] Brian Ellis, *Rational Belief Systems* (Oxford England: Basil Blackwell, 1979) 28.
[18] Bas C. van Fraassen, *The Scientific Image.* (New York: Yale University Press, 1980) 12.

The focus of this chapter is to briefly describe the rationale to posit the existence of unobservables and why Bas C. van Fraassen believes metaphysical or unobservable concepts like protons, electrons, and photons cannot be legitimately shown as real entities. Before we begin, we need to define the term *scientific realism* in relation to our discussion on unobservables. It can be argued that scientific realism consists of three distinct theses: First is the metaphysical thesis, and it suggests that the world has a mind-independent structure. One aspect to this structure is observable and the other unobservable. The second is the semantic thesis, and it says that we are to understand scientific theories only as representational models of reality and not actual descriptions of reality. The third is the epistemic thesis, and it maintains that mature scientific theories are successful and well confirmed, thus suggesting that our scientific theories are *at least* approximately true.[19] Briefly, scientific realism is the view that scientific explanations, to some degree, represent how the world is. Back to the original point, scientific realism pertains to the unobservables debate, seeing that it advances the notion that unobservables are real in some respect. Moreover, the unobservables debate has its roots in antiquity. However, this chapter will address two more recent and very influential papers on the topic. The first paper is titled "The Ontological Status of Theoretical Entities," by Grover Maxwell. The second is titled "The Methodological Character of Theoretical Concepts," by Rudolf Carnap. After we have gone through the similar views of these two papers on unobservables, our discussion will change focus: The focus will turn to van Fraassen's criticism of unobservables via his concept of *empirical adequacy*. Finally, we will look at some criticisms that philosophers of science have presented against van Fraassen's account of empirical adequacy.

[19] Stathis Psillos, *Philosophy of Science A–Z*, 226–227.

Section 1

The Ontological Status of Theoretical Entities

Maxwell addresses some of the opening questions of this chapter in his theoretical entities essay. Moreover, the key point to Maxwell's paper is to demonstrate that the observable and unobservable distinction is not always clear. Maxwell's starts this enquiry into the difficulty of demarcating what is observable and not unobservable by introducing what he calls a "pseudohistorical introduction to the problem of unobservables" (which sketches the early development for the hypothesis that bacteria and viruses are some of the leading causes of illness in humans).[20] Maxwell asks his reader to consider his pseudohistorical example prior to the invention of the compound microscope so his readers can conceptualize a time where bacteria and viruses were unobservable.

Let us consider Maxwell's pseudohistorical introduction in some detail. Maxwell discusses why unobservables cannot just be theoretical constructs. For example, Maxwell's fictional character, Mr. Jones, hypothesizes that unobservable bugs (crobes) are responsible for human related illnesses and death. Mr. Jones suggested that disinfecting items—either by using disinfectants like "toxic preparations" or by bringing items that have been in contact with ill people to high temperatures would prevent the spread of illnesses to uninfected persons.[21] Mr. Jones' crobes hypothesis was tested and rendered spectacular results. The death rate in ten years had dropped by 40%. We cannot assume these crobes are simply theoretical constructs, as we can clearly see a correlation between disinfecting and the human mortality rate, and by addressing the mortality rate we can infer that our hypotheses about crobes must be, in some respect, probably true. If crobes were simply theoretical

[20] Grover Maxwell. "The Ontological Status of Theoretical Entities." *Minnesota Studies in the Philosophy of Science* 3 (1962): 21.
[21] Ibid., 22–23.

constructs, they could not explain why people got ill and why the mortality rate had dropped by 40% in such a short period of time.[22] From the fact that the crobes hypothesis is testable and rendered positive results, we can safely assume we know something factual about the nature of crobes, i.e., we can limit their reproduction and their harmful effects by methods of disinfecting.[23]

Mr. Jones was fortunate to see the invention of the compound microscope. The compound microscope allowed scientists to see crobes for the very first time; as a result, we can openly accept a realist position towards the existence of crobes after the invention of the compound microscope. However, some can justifiably take a sort of phenomenalist stance, i.e., crobes do not actually exist they just appear to exist. Another position that can also be maintained towards crobes is that what people actually witnessed under a microscope were not crobes at all, but simply shadows or images of what they thought were crobes. To conclude, Maxwell's position on the unobservables is that the bifurcation between the observable and unobservable is not necessarily clear, and it is obvious that unobservables, in some cases, are more than mere theoretical constructs.

The Methodological Character of Theoretical Concepts

This now brings us into Rudolf Carnap's paper titled "The Methodological Character of Theoretical Concepts." Carnap is not particularly an advocate of classical metaphysics, yet he does maintain a position that allows for unobservables in science. What makes Carnap's position unique is the fact that he takes a syntactical approach to scientific unobservables. For example, Carnap maintains there are two types of languages in science and they are both compatible—the first language is theoretical,

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[22] If crobes are theoretical entities, then there is gap between theory and practice. Practice in this instance is the action of disinfecting items that have been in contact with ill people. Crobes cannot be entirely theoretical, as we have found a way to limit their harmful effects.

[23] Ibid., 22–23.

or metaphysical, and the other physical. An unobservable, for Carnap, is an expression of a theoretical term that is determined by the axioms of its theory. The physical language of science is the recording of observable phenomena by scientists. For Carnap metaphysical terms are meaningful when they are rationalized by "correspondence rules."[24]

Correspondence rules are the means to link theoretical terms to observational terms, e.g., the term *mass* suggests the weight of something. The term "weight" can be expressed through the correspondence rule as: the *mass* of object *a* is *heavier* than the mass of object *b*. The metaphysical concept of mass is now understood via the observation predicate *heavier*. For Carnap, unobservable concepts may be expressed in the physical language of science. Another way to illustrate this point is via scientific experimentation. For example, we can observe an electron in a cloud chamber, but we can also distinguish an electron from an alpha and beta particle by simply tracking the variance in their path patterns. The way an alpha and beta particle and electron behave in a Penning trap can be expressed via the physical language of experimentation. Another method of how unobservables may be legitimately expressed, according to Carnap, is via the Ramsey Sentence.[25]

There are theoretical concerns with both Maxwell's and Carnap's positions on the unobservable.[26] The intent of these two articles is not to demonstrate the possibility that unobservables may exist. The intent, rather, is to illustrate ways to legitimately speak of unobservables, i.e., by postulating the existence of unobservables we are able to explain the underlying mechanisms that lead to observable phenomena. In sum, Maxwell's paper gives us a rational approach to posit the existence of unobservables. He rationalizes them by making a

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[24] Rudolf Carnap, "The Methodological Character of Theoretical Concepts" (Minneapolis: University of Minnesota Press 1962, *Minnesota Studies in Philosophy of Science* Vol 3): 47–49. To get a "Ramsey-sentence of a (finitely axiomatisable) theory we conjoin the axioms of the theory in a single sentence, replace all theoretical predicates with distinct variables, and then bind these variables by placing an equal number of existential quantifiers in front of the resulting formula…". Stathis Psillos, *Philosophy of Science A*–Z, 208.

[25] Carnap makes this point more explicit in his paper titled "Empiricism, Semantics, and Ontology." *Revue Internationale De Philosophie* Vol 4, no. 11 (1950): 20–40.

[26] For van Fraassen's criticisms on these two papers see: *The Scientific Image* (New York: Clarendon Press Oxford: 1980) 13–19.

correlation between the hypothesis of disinfecting and the mortality rate. Carnap's syntactical approach gives us a means to give metaphysical concepts content, i.e., unobservables can be expressed via observational and operational terms. The common ground in both of these articles is that it gives two distinct ways to talk about unobservables.

To conclude this section, we can take a piecemeal approach to the problem of unobservables, meaning there are many areas in the philosophy of science that either try to rationalize or defeat the existence of unobservables. In essence, what we have examined is two ways in which we may legitimately speak of unobservables: in one respect unobservables objectively exist. In the other respect, the existence of unobservables is rationalized by linguistic terms. In our next discussion, we will look at van Fraassen's skepticism towards unobservables via his empirical adequacy concept.

Section 2

Empirical Adequacy

Our current discussion will serve as introduction to Bas C. van Fraassen's critique of unobservable/metaphysical concepts. To illustrate this point, we will work from van Fraassen's older criticisms of unobservables, i.e., *empirical adequacy*, to his more recent *empirical stance* in the following chapter. For van Fraassen science discusses the nature of things it investigates, so the following argument can be made: The language of science assumes the objects it investigates may actually exist. In this regard, science is concerned with ontology, an ontology that does not only investigate things that are observable but unobservable as well. According to van Fraassen, if metaphysics is an extension of science and if it too utilizes the same method of inference to justify the existence of metaphysical entities, then the existence of these entities cannot be justified. Van

Fraassen is skeptical that inference to the best explanation can justify metaphysical claims. This is based on his argument that the epistemic or explanatory virtues are ambiguous terms.[27] If it is true that the explanatory virtues are ambiguous, then it is difficult to rationalize them as evidence that support metaphysical and observable claims. At best, science can only give us, what van Fraassen calls, *empirically adequate* explanations.

Empirical adequacy is a recurring theme in many of van Fraassen's works, so what is empirical adequacy? It is a doctrine that suggests our scientific explanations are only empirically adequate and not true. Van Fraassen's rationale is that there is a gap between our scientific explanations and the realities they try to explicate. Scientific explanations, at best, only describe the observable consequences of our theories. Moreover, van Fraassen argues that we cannot directly see the consequences of unobservables, so it is best that we abandon metaphysical concepts. The goal of van Fraassen's concept of empirical adequacy is to remove the notion of truth from science when it is referenced to theories and hypotheses/explanations. In sum, empirical adequacy is a means to speak of scientific explanations without the commitment that they are true and/or dependent on some kind of unobservable.

Philosophers of science have also challenged van Fraassen's empirical adequacy concept, and we will now visit some of these criticisms.

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[27] van Fraassen, *The Empirical Stance*, 16.

Criticisms against van Fraassen's Empirical Adequacy

There is a theoretical distinction to how scientific theories are understood among philosophers of science: they are the semantic view and the syntactical view of theories. This distinction is important, as it plays a central role in the criticism posed against van Fraassen's concept of empirical adequacy. The core difference between the semantic and syntactic understanding of scientific theories is this: The semantic view elucidates its subject matter by the use of models like mathematical formulae versus theoretical constructs like unobservables. For example, Carnap's syntactical approach makes this distinction: There are two kinds of languages contained within science, one is theoretical and the other is observational. Carnap argued that both languages are indeed compatible with each other via correspondence rules. In short, the strong syntactic approach assumes that first-order logic provides the framework to link the different languages of science thus providing better and more robust scientific explanations.

Here is where the contention rests. Van Fraassen's empirical adequacy concept assumes a semantic understanding of scientific theories. Moreover, van Fraassen's commitment to the semantic understanding of scientific theories, he thinks, allows him to maintain a consistent skeptical position against the existence of unobservables. There exists a correspondence between Lipton and van Fraassen precisely on this point, and we shall now visit it. Lipton has argued that it is difficult for van Fraassen to renounce the existence of unobservables when a scientific theory is made empirically adequate by the use of some unobservable.[28] To quote Lipton, van Fraassen "is entitled

[28] Paul Dicken and Peter Lipton. "What Can Bas Believe? Musgrave and van Fraassen on Observability." *Analysis* 66, no. 3 (July 2008): 226–233.

to believe a theory's claim that an entity is unobservable, since if that claim were false, the theory would not be empirically adequate."[29]

Van Fraassen's response to Lipton's above critique is that empirical adequacy is wedded to a semantic understanding of scientific theories, and Lipton's critique against empirical adequacy assumes a syntactical approach, thus rendering his critique moot.[30] Here is the rationale. Van Fraassen upholds a semantic approach to scientific theories, as models best interpret theories and sentences contained within theories themselves. The justification for van Fraassen's position is grounded on the argument that the syntactic approach has led to difficulties of understanding the meanings of theoretical terms. By taking a semantic view to scientific theories, this minimizes the need for extra-linguistic terms like unobservables and theoretical terms, as one does not need to move beyond the models that are entailed within a theory.[31] In sum, van Fraassen may now believe in unobservables in the semantic view of theories, as unobservables have no objective existence, only representational importance through models (like mathematical formulae).

There seems to be an inconsistency with van Fraassen's above position on unobservables, seeing that he has argued that the genuine measure of a theory's truth does not extend beyond observables. Van Fraassen's response against Lipton's above critique may get him out of the doghouse, but that does not dismiss van Fraassen's arguments on why unobservables are to be abandoned. It seems van Fraassen needs unobservables to render his empirical adequacy sound. Conceivably, van Fraassen needs unobservables because they explain the mechanisms responsible for observable phenomena. This being said, "are the distinctions in models more or less real than the distinctions in vocabulary?"[32]

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[29] Ibid., 233. We will not get into more of the particulars of this point as that will take us far a field of the topic of this work—all that is important is to acknowledge that van Fraassen cannot actually do away with unobservables.
[30] F. A. Muller, and Bas C. van Fraassen. "How to Talk about Unobservables." *Analysis* 68, no. 3 (July 2008): 197–205.
[31] van Fraassen, *The Scientific Image*, 43–44.
[32] I would like to thank Professor Daniel McArthur for this point (personal communication).

The answer to the above question is *no*. Perhaps the best way to illustrate this point is by looking at a challenge posed to the semantic view of theories. It is difficult to understand how mathematical formulae empirically relate to the external world. Or better put, models do not necessarily fare any better at relating to the physical world than distinctions in vocabulary. For example, Newton's inverse-square law explains gravitational pull between two bodies, but the law does not necessarily give us an empirical description of what gravity is.[33]

Van Fraassen has met the above challenge with the following answer: "theories should be seen as mixed entities: they consist of mathematical models plus theoretical hypotheses…. Theoretical hypotheses have the form: the physical system X is, or is very close to, M–where M is the abstract entity described by the model."[34] Van Fraassen needs unobservables to make his empirical adequacy consistent, so he introduces unobservables back in a roundabout way. Whether or not van Fraassen's use of unobservables is or is not justifiable is outside the scope of this work, as van Fraassen brings a more powerful argument against unobservables via his criticism against the scientific method of inference to the best explanation, which will be discussed at length in the next chapter.

In conclusion, the first section of this chapter discussed two legitimate ways we may speak of unobservables. This discussion also included the syntactical approach to understanding scientific theories. The second section discussed van Fraassen's dismissal of unobservables by suggesting that scientific theories are only empirically adequate, as there is no objective way to link unobservables to their observable causes. However, if we are to remove unobservables from scientific explanations, we remove the underlying causes that explain observable phenomena. In short, van Fraassen's empirical adequacy is a means to suggest that we should be taking a pragmatic approach to scientific

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[33] Newton never claimed that his inverse law gave an actual description of gravity. I am using this example in this particular way to illustrate how our scientific models do not actually represent how the world actually is.
[34] Psillos, *Philosophy of Science A–Z*, 228–229.

explanations versus believing that scientific explanations are true. Nonetheless, we have also acknowledged that van Fraassen's concept of empirical adequacy is still reliant on unobservables in order to put it into practice.

Chapter 3

Bas C. van Fraassen & Peter Lipton: On Scientific Explanations & IBE

"…we infer the explanations precisely because they would, if true, explain the phenomena."

Peter Lipton[35]

"The very phrase "inference to the best explanation" should wave a red flag for us. What is good, better, best? What values are slipped in here, under a common name, and where do they come from?"

Bas C. van Fraassen[36]

What we have gathered thus far is that universal skepticism, in whatever form, denies the possibility for knowledge to be objective. We have also discussed two ways in which we can speak of unobservables in a scientific-realist kind of way: Unobservables are more than theoretical constructs when supported by evidence, and unobservables may be expressed in the observable object language of science. However, the focus of this chapter is to discuss why Bas C. van Fraassen's criticisms of the epistemological standing of scientific knowledge claims are legitimate but also problematic in some respects. This is explored by van Fraassen's criticisms of IBE. Later we shall also discuss why

[35] Peter Lipton, *Inference to the Best Explanation,* 56.
[36] van Fraassen, *The Scientific Image*, 13.

Peter Lipton is an advocate of IBE. Seeing that this chapter has multiple tasks, this chapter will be broken down into two sections. The first section will discuss the works and positions of Bas. C van Fraassen and Peter Lipton on scientific explanations. Their works include van Fraassen's *The Scientific Image* and *The Empirical Stance* and Peter Lipton's *Inference to the Best Explanation*. The second section will be a critical evaluation of both van Fraassen and Lipton's positions on scientific explanations. Before we start, let us recap the definition of IBE as described by Lipton: "According to the model of Inference to the Best Explanation, our explanatory considerations guide our inferences. Beginning with evidence available to us, we infer what would, if true, provide the best explanation of that evidence."[37] Lipton acknowledges the above description is not the entire picture of what IBE entails; nonetheless, this is the barebones concept of IBE.

Section 1

The Scientific Image

In *The Scientific Image*, van Fraassen puts forth two explicit arguments as to why scientific claims reached via the method of IBE are dubious. These two arguments are connected but one explicitly includes an attack on scientific unobservables. Van Fraassen's first argument begins by asking the question, "What is meant by saying that we all *follow* a certain rule of inference?"[38] If we follow the rule of IBE as if it were a rule of logic, he claims this is too literal and restrictive seeing that the rules of logic are rules of permission. His second argument states that for IBE to assert the likeliness of a realist claim being true, its advocates must assume a further premise. Quoting van Fraassen, "we need to be committed to belief in one range of hypotheses before the rule can be applied. Then,

[37] Lipton, *Inference to the Best Explanation*, 1.
[38] van Fraassen, *The Scientific Image*, 20.

under favourable circumstances, it [IBE] will tell us which hypothesis in that range to choose."[39] Let us now unpack these arguments.

So what does it mean to say that we follow a *certain* rule of inference? According to van Fraassen, if we are to assume IBE is like a rule of logic such as modus ponens, we must be willing to believe that the conclusion that follows from the premises is true, while dismissing the conclusions which contradict the one we must accept. To van Fraassen, IBE seems to be more of a psychological hypothesis, seeing that IBE helps one rationalize what things they are willing and unwilling to accept as evidence. In sum, van Fraassen maintains that IBE is not like a rule of logic, as it does not give us permission to move from evidence to explanation. IBE, at best, may be considered an empirical program because "we are always willing to believe that the theory which best explains the evidence is empirically adequate (that all the observable phenomena are as the theory says they are)."[40] In fewer words, his view is that IBE is not a rule, seeing that it does not indicate how to choose or evaluate evidence, thus making it difficult to justify why one believes one explanation is true while another is false based on the evidence. We should rather be willing, he says, to believe a theory is empirically adequate versus it being true, as any explanation can be given to account for any particular phenomena.[41]

Let us now move on to van Fraassen's second argument. Van Fraassen claims IBE accepts an explicit premise, i.e., *all regularities in nature have an explanation*. This entails an assumption that among all competing explanations that describe one particular phenomenon, one explanation is true and all the excluded ones are false. According to van Fraassen, IBE only works if someone decides not to remain neutral between possible explanations. Moreover, in his view, following the method of IBE does not necessarily suggest that the winning explanation is true. His point is that IBE does not

[39] Ibid., 21.
[40] Ibid., 21.
[41] Van Fraassen's position being akin to Pyrrhonian Skepticism has been mentioned in Chapter 1.

allow one to be neutral, but rather one is forced to accept one explanation among the other competing explanations.

There is a second part to this argument. Van Fraassen questions the criteria IBE employs for choosing one explanation, or the *best explanation*, over the competing others.[42] The criteria used to identify the best explanation are referred to as the epistemic virtues. Some of the common virtues in science include but are not limited to: *predictive accuracy*, *internal coherence*, *external consistency*, *unifying power, fertility*, and *simplicity*.[43] Van Fraassen asks the question: what is the best explanation and how do we acquire it? The method of IBE suggests the best explanation is the one that best encompasses these virtues composed with the competing lot of explanations for the same phenomenon. Van Fraassen does not mention all of the above virtues in this particular text, but he does have a general critique against them. He asserts the virtues are, generally speaking, vague concepts. However, he does mention one particular virtue and he does argue against it in this work (the virtue is explanatory power).[44]

Van Fraassen sees a particular danger in trying to find explanations for natural phenomena. The danger is we will become more reliant on hidden, or unobservable, variables to justify these explanations. Utilizing unobservables to explain phenomena is problematic seeing that the "realist yearnings were born among the mistaken ideals of traditional metaphysics."[45] Explanatory power is the ability of a theory or hypothesis to adequately explain the phenomena within its subject matter, and this usually does entail some use of unobservables (this was discussed in chapter 2 via the idea that unobservables assist in enriching scientific explanations). Van Fraassen calls unobservables into

[42] These are the virtues he explicitly names: simplicity, strength, and coherence. Ibid., 16.

[43] McMullin, "Values in Science" (PSA: *Proceedings of the Biennial Meeting of the Philosophy of Science Association*, Vol. 2 1982), 16–17.

[44] A discussion between van Fraassen and Paul Churchland has taken place on this topic of virtues. Our discussion will be limited to van Fraassen's *Empirical Stance*. See: Paul M. Churchland, "The Ontological Status of Observables: In Praise of the Superempirical Virtues." *Images of Science: Essays on Realism and Empiricism, with a Reply from Bas C. Van Fraassen*, ed. Paul M. Churchland & Clifford A. Hooker. (University of Chicago Press, 1985), 35–37 &. 284–289. See also *The Empirical Stance,* 16.

[45] van Fraassen, *The Scientific Image*, 23.

question by claiming that the epistemic virtues, which are used to justify unobservables, are ambiguous concepts. Van Fraassen then argues that there is no need for unobservables and still have a perfectly sound account for scientific explanations. Van Fraassen gives this position credence by advocating his empirical adequacy approach.

His empirical adequacy approach asserts that observable regularities exist in nature and it may be a fact that observations line up with a specific theory. However, it is still quite possible that observable and unobservable explanations are not what make a theory good nor are they needed to assist our understanding of the world.[46] The point, then, is that there may be regularities in nature and yet there may be no definitive explanation or definitive means to prove the chosen explanation is true. (The above point expresses the principle of *underdetermination of theories by evidence*).[47] It is obvious as to why van Fraassen asserts scientific explanations are just empirically adequate versus being objectively true. Another way to phrase van Fraassen's empirical adequacy principle is this: The aim of science is not necessarily concerned with the objective reality of how things are; science's principle aim is to tell us its truth of the things it can observe, or to put it differently still, scientific explanations simply *save the phenomena*.[48]

These are only a few arguments van Fraassen advances against scientific realism and unobservables in this particular text. Moreover, it would be unjust to criticize van Fraassen's formulation of IBE as a "rule" seeing it may take his arguments out of the context he was writing. In *The Empirical Stance*, van Fraassen's concept of IBE is the current and accepted norm among philosophers of science such as Lipton.

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[46] van Fraassen, *The Scientific Image*, 24.

[47] Underdetermination of theories can be understood to mean two things: first, evidence cannot prove the truth of any given theory. Second, the evidence supporting a theory cannot suggest the probability of the theory being true. Psillos, *Philosophy of Science A–Z*, 253–254.

[48] *To save the phenomena*: in some circumstances scientific explanations are chosen or modified to help explain an observable phenomenon—this suggests scientific explanations are not necessarily true but fabricated or manipulated to explain observable phenomena.

The Empirical Stance

In *The Empirical Stance*, van Fraassen asserts that past empiricist rebellions that were designed to defeat metaphysics have failed. (As a note, not all of his arguments for this statement need to be addressed, nor does the entire history of the rationalist and empiricist debate to make the next point clear. However, some arguments are needed in order to see how the above statement leads to his empirical stance.) The British empiricists tried to undermine the existence of a priori knowledge advocated by the rationalists. They did this by trying to debunk a priori knowledge by postulating that the human mind is born a clean slate, and any knowledge one has gathered must have come through their senses. According to van Fraassen, the empiricists and metaphysicians, were advocating an ontological position, i.e., that the world is intelligible and has certain features that are discoverable. This also includes the assumption that unobservables are intelligible via empirical data such as methods of detectability and experimentation. In sum, the empiricists maintained that what one comes to know about the world is simply derived from their senses. (It is also important to note that what van Fraassen titles "philosophy" is not metaphysics but empiricism.)[49]

Van Fraassen concludes that the empiricists are just as dogmatic as the rationalists: Principle Zero brings this point to light.[50] The formulation of Principle Zero is: "For each philosophical proposition X there exists a statement X such that to have (or take) position X is to believe (or decide to believe) that X+."[51] Principle Zero may also be used to express the following about philosophical propositions: Philosophical propositions, which also include metaphysical ones, assume true or false statements, and depending on what one decides to believe, or not believe, is

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[49] van Fraassen asserts that the philosophical position of empiricism was adopted into the sciences; hence, science entails a philosophical component.
[50] The idea van Fraassen is conveying with Principle Zero is this: for every philosophical or scientific proposition one accepts, they must also except some prior proposition as well. The danger is that accepting prior propositions can potentially lead one to an unjustifiable regress of justification.
[51] van Fraassen, *The Empirical Stance*, 41–42.

true about a statement, one is committed to the conclusions that follow. Moreover, the formulation of Principle Zero also applies to empirical propositions as well. For example, "[t]o be an empiricist = to believe that E+ (the empiricist dogma)."[52] One of the goals for empiricism was to debunk the dogma of a priori knowledge, yet empiricism formulated its own dogma about knowledge acquisition, i.e., all knowledge comes through the senses. Principle Zero illustrates that there may be a potential problem of circularity and infinite regress if we are to take empiricist and metaphysical dogmas to justify explanations. The empiricist criterion of knowledge acquisition leads to circularity seeing that explanations entail a description of empirical phenomena to justify the explanation. If we take the a priori approach to justify claims, we are led into the same infinite regress. The idea is that explanations, generally, do not stand on their own seeing that they are contingent on some other prior explanation. Thus, justifying one explanation might need to be justified by some other prior explanation; hence, potentially leading us into an infinite regress of justification.

So what does it mean to be a scientist or an empiricist? For starters, it assumes knowledge is obtainable and there must be a process or method to obtain it. One generally agreed upon method to knowledge acquisition is induction (in the wide sense this includes IBE). Given what has been said so far about van Fraassen's view on IBE, how can van Fraassen assure us that we can obtain a science and philosophy that is not dogmatic? The answer to this question is his empirical stance. First, let us revisit his more explicit argument against the epistemic virtues. If the truth of an explanation is contingent on the explanatory virtues, "may we be shown the balance, the gauge, the units, the scale? As long as we have nothing like that, the defence of ontology as scientific points only to the form its theory and theory choice take."[53] The above quotation is van Fraassen's main critique against the epistemic virtues, but there is more to this point. Philosophy and science are dogmatic seeing that they use the explanatory virtues to illustrate the probability of their

[52] Ibid., 45–46.
[53] Ibid., 16.

explanations to be true, yet the virtues are not definable terms.[54] Hence, the move from virtues to explanation is not legitimate seeing that the explanatory virtues cannot be defined. Instead, the explanations that justify our theories are loosely based on one's subjective understanding of the explanatory virtues. Van Fraassen's goal is to make science and philosophy less dogmatic. He believes this is possible by finding a legitimate means to violate Principle Zero, i.e., to endorse his stance.

Van Fraassen has demonstrated a genuine concern with empiricism and science: Empiricism and science are dogmatic seeing they assert their claims of reality are true based on the explanatory virtues. As discussed, there is a legitimate concern with how the virtues are construed. Van Fraassen wants an empiricism and science that is less dogmatic with their claims. This is how van Fraassen goes about achieving this: "A philosophical position can consist in a stance (attitude, commitment, approach, a cluster of such—possibly including some propositional attitudes such as beliefs). Such a stance can of course be expressed, and may involve or presuppose some beliefs as well, but it cannot be simply equated with having beliefs or making assertions about what there is."[55] In fewer words, the goal of the stance is simple: scientific and empirical claims are not objective truths but attitudes towards what exists since the explanatory virtues can always be called into question due to their ambiguity.

Van Fraassen suggests that the past materialist movement in philosophy is misled by false consciousness.[56] To give this last point some credence, van Fraassen suggests materialism may indeed be a stance versus being a true thesis about how the world is if it can escape the boundary of Principle Zero. For example, the way *matter* is understood within the context of particle physics, in

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[54] Ibid., 16. Van Fraassen does believe that the virtues still have a role in scientific explanations, i.e., their roles in scientific explanations do not change. It is our perspective of the virtues that need to change from a realist position to a purely pragmatic one.
[55] van Fraassen, *The Empirical Stance*, 47–48.
[56] Ibid., 57–60. Van Fraassen is arguing that the concept of materialism changes when discussed in different contexts. Not only within the context of science and philosophy, but in time and space as well. The idea is that the concept of materialism, and metaphysics, is a by-product of its contextual use.

Cartesian Dualism, and in Newtonian Physics is different from the philosophical idea that "all that exists is matter in motion." Van Fraassen argues that the concept of matter becomes inconsistent when it is formulated within different contexts like the individual sciences and philosophy. Here is a more concrete example: if electrons are made of matter and it is believed that electrons are able to disappear and reappear in space, is this not an example of an immaterial substance introduced by physicists into the material world?[57] If we take materialism as the correct thesis about how the world is, we would be buying into *false consciousness* because we would be ignoring the inconsistencies with the concept of matter across different contexts, i.e., paradigms.

Here is a question: Are we to throw away materialism or simply believe that it is a useless doctrine? Van Fraassen implies that the answer is no, as philosophy and science add value to the world. However, there can be no definitive claims about how the world is; in his view, there are only stances due to the problem of evidence. In conclusion, if materialism is indeed the correct thesis of what exists, then there should not be any major inconsistencies with the materialist doctrine across the different sciences and philosophy that use materialism as their theoretical starting point to explanations. Since these inconsistencies exist, van Fraassen argues that the sciences, and philosophy, may simply be stances. His point is that if science and philosophy would drop their commitment about what exists is true, then they would become less dogmatic, and this is how science and philosophy could legitimately violate Principle Zero.

[57] Ibid., 52–53.

Inference to the Best Explanation

Peter Lipton claims the purpose of his book, *Inference to the Best Explanation*, is to give a detailed account of IBE.[58] More importantly, Lipton's position, in contrast to van Fraassen, is that explanations, reached via the method of IBE, can lead to explanations that are approximately true descriptions of reality. This section will introduce Lipton's concept of IBE, but our first order of business is to discuss some of Lipton's models of explanations. Lipton believes, "we have a practice of giving and judging explanations."[59] However, he says that we do not necessarily have a good account that describes how we give and judge our explanations. Lipton maintains that there are at least six models of explanation, yet he suggests the first five are problematic and maintains the causal model is the most useful description of what scientific explanation entails. The models of explanation are: <u>reason</u>, <u>familiarity</u>, <u>deduction</u>, <u>unification</u>, <u>necessity</u>, and <u>causality</u>.

We are now going visit each of these models to see how they try to illuminate and justify scientific explanations. Our first model is reason. As the title suggests, we give reasons to justify explanations. For example, we can give reasons to why a building has collapsed or why an automobile collision has occurred. It is intuitive that giving reasons to why the building collapsed or the automobile collision occurred is useful. Nonetheless, it can be argued that giving reasons to justify explanations is illusory, as giving reasons does not account for the difference between "knowing" and "understanding" why a specific phenomenon occurred. Using Lipton's example can illuminate the above point: Seeing snowshoe tracks in the snow presupposes that someone has made the tracks, but there is a difference between knowing and understanding why a person decided to walk in the snow. For example, we understand how the tracks are made in the snow, but there is no

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[58] Lipton, *Inference to the Best Explanation*, 2.
[59] Ibid., 23.

reason to believe that a person made the tracks in the snow nor can we know why they walked in the direction that they did. In conclusion, reasons may be used to justify our beliefs to why something has occurred, but our beliefs have nothing to do with why something is the case.

Our second model of explanation is familiarity. Familiarity can be described as understanding something by analogy. Again, Lipton's example will be used to clarify this point. It can be difficult to explicate how Darwin's theory of natural selection is responsible for speciation in nature. The mechanism of natural selection can be better understood by the analogy of artificial selection, as the mechanism of artificial selection explains how certain traits are passed down from one generation to the next by animal breeders. For example, animal breeders breed animals for their aesthetic appearances and other desired characteristics. Explanations by familiarity, however, are problematic because they do not help explain "Why certain phenomena are familiar in the first place."[60] For example, even if we were to give an exhaustive explanation as to why artificial breeding is akin to natural selection, artificial breeding does not explain what random genetic mutations are. It is also worth noting there are more sophisticated issues with the familiarity model; however, the point is that no analogy can precisely capture all aspects of the comparison it is intended to explicate.[61]

The third model of explanation is deduction, also known as the deductive-nomological model. This model of explanation illustrates deduction by the following: it utilizes initial conditions, plus the use of a natural law, to explain an event or fact. For example, astronomers use the redshift phenomena to determine if galaxies are moving closer or away from us. The redshift is explained via the Doppler Effect. (The Doppler Effect is the apparent change in frequency of a wave caused by relative motion between the source of the wave and the observer.) For example, by using high-

[60] Ibid., 24–25, 56.

[61] If it is not clear by what Lipton means by familiarity this is what he means: an explanation can be clarified by some other explanation that has similar features as the explanation that needs to be clarified.

powered-telescopes we can measure the wave frequency of light waves omitted by a galaxy to determine if it is either moving towards or away from us. Lipton suggests that there is a major flaw with the deductive-nomological model of explanation. For example, we appeal to the redshift to explain the galaxy's recession, yet the redshift does not explain why the galaxy is receding away from us.[62] In colloquial terms, the use of initial conditions plus a natural law to deduce an explanation for observable phenomena does not necessarily explain the cause for that phenomenon. Perhaps this point can be better explained by another example. We can use the laws of geometry and optics to measure a shadow of a flagpole to predict its height, yet these laws do not give us a causal explanation for why the flagpole is the height that it is. (The flagpole critique was advanced against Carl Hempel's deductive-nomological account of explanations.) The idea is that *common causes* cannot be explained via initial conditions plus the use of some law due to the fact that the deductive-nomological model does not give any *causal* explanation for why an observable phenomenon occurs. If the deductive-nomological model could give causal explanations, it would give us an explanation as to why the galaxy is either moving away or towards us, and why the flagpole is the height that it is. It is not being suggested that all explanations are nomological or that natural laws are not important to scientific explanations. The point is that nomological explanations do not necessarily give us very good causal explanations for certain phenomena.

Our next model of explanation is unification. The concept of unification is much more difficult to describe and analyze, as it is difficult to illustrate how one theory fits in with other theories. (The idea is that the unification of our theories makes the regular patterns we observe in nature truer.) In order to show how one theory is connected to another theory (or theories) we need to know *why* these theories are connected in the first place. However, trying to explain why theories are connected to some larger pattern of phenomena can prove problematic. For example, it is quite

[62]Ibid., 26–27.

possible that one theory is rationalized by some kind of evidence, yet the same evidence may not rationalize a theory that fits into another theory. In such circumstances the model of unification can hinder the process of asking why there is such unity in explanations (especially if the explanation is self-unifying). The idea behind the last point in brackets is that if an explanation is justified by its causes it becomes circular.

Another problem with unification is that it cannot account for the most popular types of explanations, such as singular causal explanations. Single cause explanations can sometimes be better explained by their causes versus an appeal to the unification of explanations. To conclude, to obtain unification among different paradigmatic explanations is difficult to achieve, i.e., not all scientific explanations can and will necessarily unify with explanations and evidence from different sciences. There is an assumption with unification. The assumption is that scientific explanations describe reality so there must be some point where scientific explanations converge since they all deal with how the world is. But it is difficult to illustrate the unification of scientific explanations seeing that one must explain why some aspect of an explanation seems to be unified with another while some other aspect is not, so the way in which we describe unification may simply be in a metaphysical or figurative sense and not an actual description of how our theories appear to be unified.

Our second last model of explanation is necessity. The necessity model of explanation assumes that phenomena occur due to necessary causes and conditions. The necessity model runs into the same kind of critique discussed with the unification model, as it can be very difficult to define the concept of necessity. For example, the conclusion to a deductive argument is necessarily true since it is deduced from true premises: this is an example of logical necessity. However, understanding necessity in the context of logic or within a schema of deduction is a narrow understanding of necessity. Within our present context of deduction, there is a problem with necessity that scientific explanations are not entirely informed by observation and laws of nature. A large part of scientific explanations are inferred from evidence, the logical entailment of theories, and the human imagination.[63] Referring back to van Fraassen, the move from evidence to explanation is not justifiable seeing that the epistemic virtues are vague; as a result, explanations are rendered questionable. In addition, if we are to claim that an outcome is necessary, we are assuming we are aware of all the necessary and sufficient conditions that lead to that outcome. Again, can we know all of the necessary and sufficient conditions to scientific explanations? The answer is *no*. But if we were to say *yes* to the above, it is quite possible that it would lead us into an infinite regress of sufficient causes that may or may not be justifiable. When the term *necessity* is used within the context of explanation, it must be used in a loose sense because that would assume that we know, with certainty, all of the prior and necessary conditions that lead to specific phenomena. However, in some cases we may know all of the necessary and sufficient conditions that lead to a specific event. For example, seeing a strip of blue litmus paper turn red when placed in a solution suggests the solution is acidic. (The necessary and sufficient conditions for blue litmus paper to turn red are that it must come into contact with an acid solution.) Nonetheless, even such examples of necessity can be called into question. For example, we still need to know the necessary and sufficient causes behind why acid and the litmus paper have the properties that they do. To conclude, there is a duality with necessity. If our understanding of necessity is narrow, like logical necessity, we cannot know the necessary and sufficient conditions that lead to a phenomena seeing the phenomena becomes self-evidencing like the litmus paper example mentioned earlier. If our concept of necessity is too loose, we can be led into an infinite regress of identifying all of the necessary and sufficient causes that give birth to a particular phenomenon.

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[63] See David N. Stamos for a comprehensive analysis of the role for scientific imagination in scientific discovery in *Edgar Allan Poe,* Eureka*, and Scientific Imagination* (SUNY Press, 2017).

Before we move on to causality, it must be acknowledged that each of these models captures some feature that tries to justify why an explanation is true. Moreover, these models of explanation were not taken at face value, meaning the shortcomings of these models were exposed to illustrate the phenomenon of explanation is not an easy one to elucidate. Nonetheless, Lipton does believe that the model of causality is indeed the best model of explanation, but more specifically because it is the more fitting model of explanation for the method of IBE.

What is the causal model of explanation? "To explain a phenomenon is simply to give information about its causal history, or where the phenomenon is itself a causal regularity, to explain it is to give information about the mechanism linking cause and effect."[64] More importantly, the causal model is able to demarcate between knowing why a phenomenon occurs and simply knowing that it does occur. In short, we may know that a particular phenomenon occurs, but we may not know the reasons why it occurs. Lipton claims that the causal model does not encounter the same theoretical concerns as our previous models of explanation. For example, the causal model does not lend itself to an infinite regress of why questions as the unification and necessity models, since the causal model can explain something without itself needing to be explained. For example, we do not need to know how our chemical theory relates to physics or all the necessary and sufficient causes to why acids turn blue litmus paper red. Turning to the reason model, explanations require reasons to give phenomena credence, yet it is legitimate for an explanation to be self-evidencing. For instance, a phenomenon being explained can also be an essential part of the explanation. For example, the redshift explains if a galaxy is moving away or towards us, but there is no need to give reasons to why the redshift exists if all we are interested in is the direction of the galaxy. The causal model avoids the issues with the familiarity model seeing that phenomena can be related, and yet we do not necessarily need to know why they are related. Finally, the causal model overcomes the objection to

[64] Lipton, *Inference to the Best Explanation*, 30.

the deductive-nomological model, as we do not need a natural law to give a cause as an explanation: "one does not need to know a law to have good reason to believe that a cause is a cause."[65]

Lipton asserts that there are three major problems with the causal model of explanation, yet we should not be so quick to abandon the model. The first problem is that we do not have a fully adequate analysis and understanding of causation. Even though this is the case with causation, we simply do not disregard it seeing that causation allows us to make inferences based on our everyday experiences. Moreover, causation is central to philosophical and scientific explanations. The second foreseeable problem with causation is that not all explanations require nor need causation to be good explanations. For example, we can utilize mathematical and geometrical laws to explain phenomena (we can insert our flagpole example to illustrate this point). The third problem with causation is that it may be too permissive and wide in its explanations: For instance, having a causal history to aid an explanation does not necessarily make the explanation good. For example, "the Big Bang is part of the causal history of every event, but explains only a few."[66] More specifically, the Big Bang may be the ultimate cause to all causes, but it does not explain why an individual may choose the salmon over the steak for their dinner. The idea, then, is a causal history of an explanation may not be entirely useful to an explanation nor does it necessarily make the explanation better, so an explanation cannot just be giving a casual history. There is still another obstacle with the causal model that needs to be overcome: "How can the causal model be developed to account for the causal selectivity of our explanatory practices?"[67]

The above question is a very important one, and it would be best to unpack exactly what it entails by formulating a more concise question. If we use the causal model of explanation to explain phenomena, how do we go about selecting the relevant elements to a casual explanation? One

[65] Ibid., 30.
[66] Ibid.,30–31.
[67] Ibid., 30–31.

answer to this question is that we selectively choose what we think is causally important or unimportant to an explanation. But this answer is not entirely useful, as it may be very difficult to identify why something is or is not important to a causal explanation. One possible way to remedy the above concern is with the fact and foil distinction. (The fact and foil distinction is a method of how to choose one explanation instead of another by showing why one explanation is better than the other—this is achieved by giving reasons to why the chosen explanation explains more compared to its competitors.) This distinction can be expressed as "why P rather than Q?" With the fact and foil approach we can try to explain the causes that lead to why P is true and why Q is false by eliminating unsatisfactory explanations for P. The advantage of this approach is that it gives us a way to compare and contrast causal explanations for one particular phenomenon, thus rendering us with the possibility that one explanation amidst the competing others is true. However, there is a drawback with contrastive explanations, which is that there is no criterion on how to go about making a contrast meaningful. For example, we can simply choose some uncontroversial observation to justify why P is true and Q is false. A simple fact or foil analysis will render the contrastive process weak and suspect if the fact and foil are not equally good in showing why something is or is not the case. In sum, there are no methods or guidelines that explain how to go about making a successful and meaningful contrastive pool of explanations seeing that it is difficult to choose what is true or false about an explanation. The question we must now ask is what else is required to legitimately claim P is true and Q is false?

Our current task is to give a rationale to how we can justify P is true and Q is false. (This point will be demonstrated via Lipton's epistemic virtues of *loveliness* and *likeliness*.) For example, a set of contrastive explanations cannot yield more than one true explanation, yet there may be circumstances where two explanations may seem true; however, one explanation must be truer than the other. The means to decide which explanation is truer is to filter the competing explanations.

One way to filter explanations is to choose only those explanations that are "live options." Live option explanations are those explanations that best describe phenomena based on the theoretical backdrop that pertain to the phenomena. For example, the conservation laws in physics are better apt to describe particle spin and decay than using fairies as a possible explanation for these kinds of particle behaviour. This current example does not necessarily indicate where two competing theories seem to be true in explaining one particular phenomenon. Back on point, our current example is useful because it explicates a two-tiered filtering of explanations that operate within IBE. This two tier filtering consists of: "one selects the plausible candidates, and a second that selects among them."[68] The method of IBE works by narrowing the pool of explanations by only choosing "live options," i.e., "the serious candidates for an actual explanation."[69] The second filter assists in choosing the best explanation among the competing lot of explanations.

The role of the epistemic virtues is to assist in determining which explanation among the competing lot is the *best*. The virtues of likeliness and loveliness assist in identifying which is the best explanation. The virtue of likeliness assists in identifying the best explanation by the following: It can be the total sum of all the evidence available for a particular explanation that makes it the most likely or plausible explanation among the other competing explanations. The loveliest explanation describes how much understanding the explanation provides about the phenomena in relation to the other explanations.[70] The best explanation is one that establishes why it is the most likely and loveliest explanation, and if the explanation is correct, it will provide the most understanding. The virtues of likeliness and loveliness are a means to give justification, or reasons, to why we may believe one explanation is better over the competing others. In sum, when an explanation encompasses the virtues of likeliness and loveliness, it suggests the explanation is true. In such

[68] Ibid.,, 59.
[69] Ibid, 59.
[70] Ibid., 57, 59, 207.

circumstances, we must accept the underlying assumption. The assumption is that it is no miracle that the chosen explanation is both the most probable and explains the most. Nonetheless, one could contest the no-miracles assumption by the under determination of theories argument.[71] For example, it does not matter which explanation is the most likely and lovely, as we cannot possibly know all the underlying causes that gave way to specific phenomena. Considering the last point, we can see why van Fraassen's empirical adequacy seems the safest position to endorse; however, we shall see that IBE fares far better than mere empirical adequacy.

Before we continue to section 2, the main point of contrast between van Fraassen and Lipton needs to be addressed in order to make the arguments in section two more clear. The major point of contrast between van Fraassen and Lipton is that van Fraassen, unlike Lipton, does not believe that the method of IBE can lead to true explanations of reality or that there is any justification to believe scientific explanations are true. Lipton maintains that we can justify our beliefs via IBE because if our inferences were true, then they would explain the phenomena. More specifically, explanations for Lipton give us a causal story as to why a phenomenon occurs, and it is the virtues of likeliness and loveliness that assist us to pick the *best* causal explanation among the competing lot. As we will come to see, Lipton's work on IBE is not infallible, but he does provide a practical account of the inferential practices of science. In conclusion, the main contrasting point between van Fraassen and Lipton is on the permissibility to move from the physical evidence which then informs the virtuous of explanations scientific explanations which is then used to justify our true beliefs on what exists.

[71] More on the no-miracles will be given later.

Section 2

Theoretical & Conceptual Issues with van Fraassen and Lipton's Position on Explanation

In this present section I will critically assess whether or not van Fraassen and Lipton's arguments can actually warrant their positions on scientific explanations. First, we will start with the most obvious criticisms against van Fraassen's position then move to Lipton. Perhaps the best way to proceed with our current task is to ask this question: Can van Fraassen's principle of underdetermination of theories truly lead to the conclusion that scientific explanations are only empirically adequate? If we reside with the position that it is illegitimate to move from virtuous explanations to true explanations of reality, then the underdetermination of theories position does seem plausible; however, can van Fraassen's underdetermination apply to all scientific explanations? The answer to this question is *no*, but to prove this we will need a more sophisticated understanding of the epistemic virtues and their role in scientific explanations. This point will be addressed later on via Ernan's work on scientific values.[72] In sum, it is being argued that van Fraassen's position is that of universal skepticism. Again, this is based on his underdetermination of theories position. Moreover, it has also been suggested that van Fraassen's empirical adequacy also closely resembles Pyrrhonian skepticism—the correlation is that the justification used to explain any phenomena could be called into question thus leaving the possibility for many equally good explanations to elucidate any phenomena. But as mentioned in the first chapter, it is extremely difficult, perhaps psychologically impossible, for any individual to truly suspend their judgments on all matters. Again, we will visit a more substantial criticism of van Fraassen's position later in chapter 4.

Our focus now is to identify some theoretical and conceptual issues with Lipton's position on IBE. (Some of the issues that will be discussed about Lipton's position will be in line with van

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[72] McMullin uses the word "values" where Lipton uses the world "virtues."

Fraassen's rationale against IBE.) We will now explore two possible criticisms against Lipton's position.The first is how many contrastive explanations are needed to establish a successful contrastive set of explanations.[73] Second, how do we choose between explanations that display the virtues of loveliness and likeliness? These two criticisms are more questions than criticisms against Lipton's position, and in trying to answer these two questions it becomes apparent why Lipton's view of IBE has some theoretical and conceptual issues.

The first question has already been partially answered in the fact and foil discussion in the previous section of this chapter. We use fact and foil to assist in finding explanations that best explain a particular phenomenon. The relationship between fact and foil is not entirely clear, as there is no criterion of how to adjudicate which fact and foil explanations are to be considered or disregarded. As mentioned earlier, choosing a simple fact and foil example does not present a strong case for explaining why P and not Q. Moreover, choosing a more sophisticated fact and foil example may not necessarily fare any better, as the principle of underdetermination of theories can be presented as a way to undercut all scientific explanations. Second, examples of fact and foil assist in answering why something is the case versus not the case. And here is where the contention rests: If one of the roles of science is to answer why something is the case versus not the case, how does science go about asking why questions? Again, we have already visited this issue in chapter 1 via van Fraassen: The type of why questions scientists ask have predetermined answers based on prior evidence and explanations; as a result, scientists only seek the answers to the questions they deem

[73] Lipton does address this concern with IBE, and his solution suggests there is a difference between hypothesis generation and hypothesis selection. The idea is that hypotheses are chosen on their probability via observations and other mechanisms that relate to the phenomena in question—hypotheses are not simply generated to accommodate the idea that all explanations are equally possible explanations (Lipton, *Inference to the Best Explanation*, 149–151). To solve this contention between Lipton and van Fraassen would be very lengthy, but this issue will be addressed later on in this chapter via McMullin's work.

acceptable.[74] In short, if contrastive explanations are part of the method of how to identify true and best explanations, we run into the above difficulties.

The second question may be more pressing on the method of IBE. It can be difficult to choose between two competing explanations seeing that one explanation may be the lovely explanation while the other is the likely explanation. The question is how do we choose between the most lovely and likely explanation? In some circumstances it may be easy to choose since we may only be interested in the most lovely or likely explanation; however, in some circumstances there may be an equal pull in opposite directions. For example, the discovery of the Higgs Boson Particle having the mass of 125 GeV (Gigaelectron Volts) did not prove nor disprove Super Symmetry or Multiverse theory; as a result, the mass of the Higgs still presented an equal pull in both directions for acceptance of either one of these two theories. Being in the predicament of choosing between the most lovely and likely explanation can be difficult because an explanation or rationale must be given as to why the loveliness or likeliness of one explanation is preferred or why one explanation was chosen over the other. The difficulties just listed can be problematic for IBE if loveliness and likeliness are the only two epistemic virtues to identify the best explanation among the pool of competing explanations. Lipton does mention that the other explanatory virtues play a role in the contrastive process and to list and define them is out of the scope of his work, but he does maintain that the explanatory virtues are a guide to inference.[75]

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[74] Lipton suggests contrastive explanations are chosen based on how plausible they are on explaining a particular phenomenon—this suggests there is an epistemic filter on how to choose explanations for the contrastive procedure (Lipton, *Inference to the Best Explanation*, 59). In many ways, van Fraassen's position can be envisaged as a critique of the use of the epistemic filter, but the filter in van Fraassen's view is too narrow since it denies unscientific explanations to be part of the contrastive pool of explanations.
[75] Lipton, *Inference to the Best Explanation*, 122, 207.

Values in Science

This now takes us into McMullin's work on the epistemic values. One of the issues that McMullin addresses and wants to overcome is the subjectivity of the epistemic values. What does this subjectivity entail? The values that scientists hold are not objective but subjective. This suggests that the epistemic values deployed by scientists are subjective concepts and they are informed by their biases versus the values being objective concepts. In short, one scientist may consider one theory better than another simply based on how he or she evaluates the value of that theory. However, McMullin does believe that science can lead us to objective knowledge.[76] McMullin makes this point clear by stating that theory choice in science is a value-based endeavour yet it is still objective. He expresses this point by what he calls the four propositions in science.[77] McMullin defines them as:

P1: The goal of science is theoretical knowledge.

P2: The theories of science are underdetermined by the empirical evidence.

P3: The assessment of theories involves value judgment in an essential way.

P4: Observation in science is theory-dependent.

Each one of these propositions has a role in scientific explanations: P1 indicates that in science it is theories that are better at explaining phenomena than laws, "and thus that retroduction,

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[76] McMullin, "Values in Science," 18: "values I will call epistemic, because they are presumed to promote the truth-like character of science, its character as the most secured knowledge available to us of the world we seek to understand. An epistemic value is one we have to believe will, if pursued, help toward the attainment of such knowledge. I have concentrated here on the values that one expects a good theory to embody." We can extent the list of values beyond the ones he gives, which will be mentioned on the next page, seeing that once a science matures we will come to see and have different values in that theory.

[77] Ibid., 14.

not induction, is the main form of scientific validation."[78] McMullin also asserts that science utilizes the method of retroduction (also known as abduction) to validate theories, i.e., we use observations to validate a theory which accounts for why an observable phenomenon occurred. P2 asserts that the truth of our scientific theories is always dubious based on the fact that an unbridgeable gap exists between our theories and the evidence used to secure their epistemological standing. P3 is the direct result of P1 and P2. Thus far, P1 to P3 leads to explanations in science being questionable based on human value judgments. P4 describes the relationship between theory and observation. McMullin argues, "P4 serves to emphasize that a thesis in regard to theory-appraisal has a broader scope."[79] It is within this scope where we come to see how the human subjectivity in science transforms into objectivity via the values: After this point has been explored, we will come to see how McMullin's work integrates with that of Lipton to give a more robust version of IBE.[80]

McMullin argues that there are at least six values that are applied in science. These values are: *predictive accuracy*, *internal coherence*, *external consistency*, *unifying power*, *fertility* and *reproducibility*.[81] A brief description of how these values apply to scientific theories will now be explored. Predictive accuracy is identified when a theory, within a science, has been proven to give good results over time. The long-term predictive success of a theory is the result of scientists addressing ways to overcome the inconsistencies present at the early developmental stages of a theory. Internal consistency measures how discrete components of a theory hinge together with no logical inconsistencies and without unexplained coincidences. External consistency measures how well a theory is consistent with already established knowledge. Unifying power is a theory's ability to bring discrete areas of enquiry together; for example, quantum indeterminism can be used to explain random genetic mutations in

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[78] Ibid., 14.
[79] Ibid., 14–15.
[80] This point has been brought to light by David N. Stamos (personal communication), forthcoming in chapter 6 of his book, *Edgar Allan Poe,* Eureka*, and Scientific Imagination*.
[81] McMullin, 15–18. (Reproducibility: McMullin means that experiments can be replicated. McMullin also believes there are other epistemic values in science out side his list).

biology.[82] Fertility is a theory's ability to make novel predictions and modify and generate useful modifications to the main concepts of a theory. The goal of scientists is to look for good theories, and good theories happen to be the ones that express more epistemic values.[83] Moreover, theories that display epistemic values are true because they have the attributes of predictive accuracy, internal/external coherence, unifying power, and fertility.

The above explanation for each of the mentioned epistemic values is by no means complete nor is it a list of all the possible values. Nonetheless, McMullin's work gives us an explanation for the importance of the epistemic values in science: "Apprentice scientists learn them [the epistemic values] not by reading a book but from watching others exercise them. They learn what to expect in a good theory. They note what kinds of things carry weight, and why they do so."[84] It is the success of past and historical theories that identifies what a good theory is, and trying to explain why a theory is good we come to see a theory's value.

Our current task is now to combine Lipton and McMullin's work on theory choice, as it will render a more complete version of IBE. For example, Lipton gives an exhaustive account of the contrastive component of theory choice, but he lacks McMullin's account of the importance of the other values in science. To illustrate the successful marriage between Lipton and McMullin's position, we will come to see how combining McMullin's understanding of the values with Lipton's contrastive explanations overcomes the theoretical and conceptual issues with IBE discussed earlier.

Going back to the first question, how many contrastive explanations are needed to establish a successful contrastive set of explanations? Lipton argued that looking at only "live option" explanations is central to achieve a fairly good number of contrastive explanations. But according to van Fraassen's underdetermination principle, live option explanations are not very useful, as there is

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82 A discussion on the details of this topic can be found in David N. Stamos, "Quantum Indeterminism, Mutation, Natural Selection, and the Meaning of Life," *Quantum Biochemistry* 2010, 843.
83 McMullin, "Values in Science", 22–23.
84 Ibid., 20–21.

no legitimate means to move from epistemic virtues and values to true explanations. In addition, the virtues of loveliness and likeliness by themselves, or combined, are probabilistically limited to concretely express truth beyond a reasonable doubt. However, an explanation derived from a contrastive pool that entails more than just the virtues of loveliness and likeliness is possible. In other words, the best explanation is one that entails more epistemic virtues than it its competitors—in a *cluster class* sense. In other words, by trying to identify a bundle, or cluster, of virtues in one explanation, within the contrasting lot of explanations is the means to identify the best explanation among the competitors. Also, in taking a cluster approach to the virtues, we can identify explanations that may not necessarily be nor need to be testable to be good explanations (for example, like string theory).

Our second question is, "how do we choose between the most lovely and likely explanation?" In taking a cluster approach we are not limited to the lovely or likely explanation, as we can use the other virtues to assist in finding the explanation that explains best. There is a further advantage to the cluster approach just mentioned for explanation choice. It was briefly stated earlier in this chapter: there are no miracles in science. The general gist of no-miracle type arguments is that "the success of scientific theories, and especially their ability to issue in novel predictions, lends credence to the following two theses: (1) that scientific theories should be interpreted realistically; and (2) that, so interpreted, these theories are approximately true."[85] By combining Lipton and McMullin's work we get a robust version of IBE. This version makes the no-miracles in science more vigorous by the fact that the *more virtuous*—overall—the explanation is, the less likely its explanatory power becomes an accident.[86] Moreover, the acceptance of the best explanation is based

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[85] Psillos, *Philosophy of Science A–Z*, 166.

[86] Hillary Putnam's defence for scientific realism is most famous by this quotation "The positive argument for realism is that it is the only philosophy that doesn't make the success of science a miracle." Hilary Putnam, "Mathematics, Matter, and Method."*Philosophical Papers* 2nd ed. Vol. 1 (Cambridge University Press, New York: 1975) 73. Moreover, this work

on accepting or rejecting its virtues and within a matter of degree of acceptance. It is also worth mentioning, there may be circumstances where two theories may seem to share an equal number of virtues but they are different in nature. However, in such circumstances there is nothing wrong with stating that the explanations of a science on a particular matter are incomplete or that scientists simply just do not know which theory/explanation to adopt. Nonetheless, in such circumstances universal skepticism is still not warranted. For example, seeing that the science is out does not warrant the position that nothing about what that science describes is unknown (this point will be discussed further in chapter 4).

Back to one of the original questions, can van Fraassen apply the principle of underdetermination to all scientific explanations? In circumstances where an explanation is highly virtuous, the burden should shift to van Fraassen to explain why the virtuous explanations does not warrant one to believe that the best and likely explanation is true. This point will be apparent in the next chapter via a concrete scientific example. However, there is a counter-argument that can be presented to undercut the no-miracles assumption working within IBE. This counter-argument is known as the *Pessimistic Induction Argument*. Larry Laudan put the argument forth in his paper titled "A Confutation of Convergent Realism." It is important to spend some time to unpack the pessimistic induction argument, seeing it is a skeptical argument against scientific realism advanced in this work and in general to IBE.

The pessimistic induction argument is an attack on scientific realism based on the assumptions made by scientific realists. Laudan claims there are four main assumptions or pillars that are used to justify scientific realism. The four pillars used to justify scientific realism are:

1: The theories in the advanced or mature sciences are successful.

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argues that the no-miracles argument is indeed a vindication for scientific realism. For a comprehensive critique against the no miracles argument and against scientific realism see: *A Critique of the Arguments for Scientific Realism* by Phil Rees.

2: A theory whose central terms genuinely refer will be a successful theory.

3: If a theory is successful, we can reasonably infer that its central terms genuinely refer.

4: All the central terms in theories in the mature sciences do refer.[87]

Laudan argues that each of these pillars is problematic based on historical examples: over all, if 1 through 4 are true, they render scientific realism suspect due to major scientific revolutions that have occurred throughout history.[88] For example, the pessimistic induction's main argument is that the pillars (considered collectively or individually) cannot warrant the realist position seeing that history is full of so-called past-successful theories that we now know to be blatantly wrong. If the realist position is indeed a consistent one, history should not be filled with examples that contradict the main pillars used to rationalize scientific realism. It is also worth noting that the pessimistic induction argument does not imply our current successful scientific theories are false, but it does attempt to throw into question the explanatory connection between empirical success and truthfulness.[89] (There is one other implicit assumption made by the pessimistic induction argument: we may understand some of our most confirmed theories as being true, but that does not negate the possibility that they may be proven false in the future by new or contradictory evidence.) As a counter-argument to the supporters of pessimistic induction, they must explain why some parts of a scientific theory or scientific paradigm remain intact and accurate after the science goes through a revolution. Perhaps the best argument against pessimistic induction is that we have not seen a Kuhnian revolution in *recent modern science*, and there has been great explanatory success in

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[87] Larry Laudan, "A Confutation of Convergent Realism." *Philosophy of Science*, Vol. 48, No 1(Mar. 1981): 23.
[88] Ibid., 24.
[89] Psillos, *Philosophy of Science A–Z*, 178.

multidisciplinary approaches to answering key scientific questions.[90] (Again, this point will be implicitly addressed in chapter 4.)

To conclude this chapter, the pros and cons concerning the topic of scientific explanations and the justification for theory choice have been discussed through the works of Bas C. van Fraassen and Peter Lipton. Moreover, Larry Laudan's pessimistic induction argument was discussed to illustrate a stronger critique against scientific realism, i.e., scientific theories cannot be true because of scientific revolutions. The next chapter will argue that scientific explanations are more than mere stances via our new understanding of IBE, and this example will also make it clear as to why Lipton's original view on contrastive explanation is not complete and that science actually employs the more robust version of IBE proposed in this chapter.

[90] What I mean by "recent modern science" is the current work being done in our most confirmed sciences, e.g., the work in physics, biology and chemistry. The concepts within the sciences just mentioned have gone though some major past revolutions, but some of their key concepts have remained consistent and reliable to this day.

Chapter 4

The Justification for Scientific Explanations via a Model Example of IBE

"Science aims to give us theories which are empirically adequate; and acceptance of a theory involves as a belief only that it is empirically adequate."

Bas C. van Fraassen[91]

"By deploying Inference to the Best Explanation we gain the advantages of both logical and causal thinking, the best of both worlds." "The more use we can make of the explanatory virtues, the closer we will come to fulfilling the exciting promise of Inference to the Best Explanation, of showing how explanatory considerations are our guide to truth."

Peter Lipton [92]

The first section of this chapter will give a scientific example of IBE, and this example will illustrate why we may believe scientific explanations are true. The model example of IBE that will be discussed is the shift that took place in palaeontology, and in particular to what caused the mass extinction of the Cretaceous-Tertiary period (C-T).[93] The second section of this chapter will critique van Fraassen for underestimating the epistemic virtues in favour of his empirical stance, and this will be explained in reference to our current scientific example.

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[91]van Fraassen, *The Scientific Image*, 12.
[92]Lipton, *Inference to the Best Explanation*, 140, 62.
[93] Luis W. Alvarez et al. (1980), "Extraterrestrial Cause for the Cretaceous-Tertiary Extinction" *Science* 208, 1095–1108. I would like to thank David. N Stamos who brought this example to my attention.

Before we get into the details of our scientific example, it must be addressed that this example is not guilty of committing the "is ought-fallacy." Because we can see a clear case for the implementation of IBE, as discussed in this work, this does not suggest that all the sciences should and do follow this precise recipe of IBE.[94] However, what is consistent among the sciences is the use of contrastive explanations with the hopes of identifying the best explanation. To conclude, the Alvarez et al. paper illustrates the method of IBE discussed within this work and the general description of how the method of IBE is applied by the sciences.

Section 1

Extraterrestrial Cause for the Cretaceous-Tertiary Mass Extinction

According to the research conducted by the Alvarez team, there were five prominent explanations as to what may have caused the mass extinction that took place in the C-T period. The team also claimed that there was no sign of a consensus on this topic among palaeontologists. Moreover, some of the explanations used to explain the C-T extinction included: "gradual or rapid changes in oceanographic, or climate conditions due to a random or cyclical coincidence of causative factors; magnetic reversal; a nearby supernova; and the flooding of the ocean surface by fresh water from a postulated arctic lake."[95] What makes the Alvarez et al. paper the ideal example of IBE is the fact that they argue contrastively for why a large asteroid impact better explains the C-T mass extinction compared with explanations of other palaeontologists. To phrase it like the Alvarez team did,

[94] A more historical example of IBE, as described here, would be Darwin's *Origin of Species by Natural Selection*, in which Darwin argues why his theory of natural selection was indeed the better explanation in comparison to Lamarck, Chambers, and creationist theories of his day.

[95] Luis W. Alvarez et al., "Extraterrestrial Cause for the Cretaceous-Tertiary Extinction," 1095.

"[n]one of the current hypotheses adequately accounts for this evidence" , i.e., the Ir located at the C-T strata line.[96] Our attention is now to look at some of the arguments to why the asteroid impact explanation is the better explanation to account for the C-T extinctions.

All of the proposed theories of what caused the mass extinctions of the C-T period were problematic due to limited evidence found in the paleontological record. Some of this evidence included: "variations in stable oxygen levels, carbon isotopic ratios across the boundary in pelagic sediments, which may reflect changes in temperature, salinity, oxygenation, and organic productivity of the ocean water."[97] The just mentioned evidence was difficult to interpret and could not necessarily explain the extent for all the mass extinctions that had occurred, but most importantly it could not explain the iridium found in the C-T strata. What makes the Alvarez hypothesis the best and likely explanation is that it can link the physical evidence found in the C-T strata to one singular cause for the mass extinctions. The smoking gun to Alvarez's hypothesis was the discovery of the abnormally high level of the platinum metal iridium (Ir) found in the C-T strata boundary line. In short, Ir is not abundantly found in the earth's crust, but it may be found at the earth's core; however, Ir is most abundant in chondritic meteorites throughout the solar system.[98] In addition, the Alvarez team also analyzed the limestone and clay layers below the C-T boundary line for Ir, but found no Ir above the normal background level, and given the high level of Ir also ruled out the possibility that the high Ir level was influenced by some crustal source.[99] The Alvarez team concluded that an asteroid impact best explains the high levels of Ir found in the C-T boundary line and the mass extinctions that followed.

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[96] Ibid., 1095, 1102.
[97] Ibid., 1095.
[98] Ibid., 1095–1096.
[99] Ibid., 1100–1101.

The Other Hypotheses: Arguing Contrastively

The best "live option" explanation for the C-T extinctions was the supernova hypothesis, but only prior to the asteroid impact hypothesis seeing that the other hypotheses had very little concrete evidence in their support. For example, the climate change hypothesis asserted that the melting of the fresh water lake caused the mass extinctions by flooding, but this explanation does not explain the abundance of Ir found in the C-T strata. The earth's reversal of magnetic field was also dismissed based on the fact that it too does not explain the abnormally high level of Ir.[100] It will now be argued why the supernova hypothesis was indeed a "live option" explanation, and why the asteroid impact is still the better explanation compared to the supernova hypothesis.

The Supernova Hypothesis

The method the Alvarez team used to identify and isolate Ir is an atomic process called neutron activation analysis (NNA). The NNA process is a means to isolate one element within a sample that contains multiple elements. The process entails bombarding a sample of the strata material with neutrons, thus causing the elements of the sample to form radioactive isotopes. By studying the spectra emissions of the isotopes one can determine what kinds of elements are contained within a particular sample. This is a general picture of how Ir is measured, our focus is now to illustrate why the supernova hypothesis is a possible hypothesis to explain the Ir found in the C-T boundary; however, we will also come to see why it is not the best explanation to explain the Ir found in the C-T boundary line and the mass extinction that followed.

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[100] The Alvarez team argued that their asteroid hypothesis was indeed the best explanation to account for the C-T mass extinction because it explained the Ir found at the C-T boundary line. However, they did not consider all possible "live option" explanations, e.g., multiple volcanic eruptions for long periods of time with the force the 1883 Krakatoa eruption could potentially account for Ir in the C-T boundary line.

The reason why the supernova hypothesis is a contender to explain the C-T extinctions is based on the fact that it can actually explain the Ir found in the C-T boundary line. As mentioned, Ir is abundant in the solar system, plus a supernova explosion close to earth could in fact explain the large amounts of Ir found at the C-T boundary line. Moreover, the Ir levels found in the C-T boundary line can be used to calculate the possible distance of the supernova to the earth. According to the Alvarez team, they estimated that the supernova would have to be about 0.1 light-years away from earth to deposit the amount of Ir the team found in the boundary line.[101] The team also calculated that the probability of a supernova occurring close to the earth within the last 100 million years would be 10^{-9}. In sum, the probability of a supernova being the cause of the C-T extinctions is highly unlikely. In spite of this fact, the evidence still places the supernova as a possible live option explanation. However, the team goes on to argue that the supernova explanation is rejected based on two new pieces of contrary evidence.

The first new piece of contrary evidence is that shortly after a supernova explosion, it is believed that some of the heaviest known isotopic metals should be formed. Some of these isotopic metals, formed by a supernova, would include metals heavier than nickel, Ir and plutonium (Pu). This being said, the team speculated that they should be able to detect high levels of Pu and Ir consistent with a supernova in the C-T boundary line. By using the NNA process, the team was able to determine that "no ^{244}Pu was detected in the Gubbio samples, with a detection limit of less than 10 percent of the amount that would be expected to accompany the measured iridium if a supernova were responsible for the latter."[102] The second piece of contrary evidence to the supernova hypothesis is: Isotopic metals formed by a supernova should be of a different composition compared to that of the standard form of Ir that is found in abundance throughout the solar system.

[101] Ibid., 1103.
[102] Ibid., 1103–1104.

The standard form of Ir comes from meteors and asteroids.[103] Moreover, the team's experiments conclude that Ir has two stable isotopes, and the two Ir isotopes found in the C-T boundary line are consistent with that of the standard and not a supernova because "a supernova would produce Ir with an isotopic ratio that might differ from that of the solar system by as much as a factor of two."[104] But more importantly, the "final result is the isotopic ratio of the boundary Ir differs by only 0.03 + 0.65 percent (means +1 standard deviation) from that of the standard."[105] From the above evidence, the team concluded that the Ir ratio in the boundary layer and the standard do not differ by more than 1.5 percent. This finding rules out the supernova as the leading cause for Ir found in the C-T boundary line, thus eliminating the supernova hypothesis as the leading cause for the mass extinction.

Krakatoa & the Asteroid Impact Hypothesis

The advantage of the asteroid impact hypothesis is that it accounts for the physical and biological evidence found in the C-T boundary line. For a start, the impact hypothesis can account for the Ir found in the boundary line, but can it explain the mass extinctions? The team believes it does, so they turned their attention to a more recent event that can shed some light on the asteroid impact explanation, i.e., the Krakatoa eruption. The similarity between an asteroid impact and a large volcanic eruption is that both emit large quantities of debris in the stratosphere that can potentially inhibit photosynthesis for long periods of time. In short, both catastrophic events have the potential to negatively impact plant growth thus possibly killing the wildlife that depends on them as a food source, thus disrupting the entire ecosystem. It was estimated that Krakatoa ejected 4km3 of debris

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[103] This evidence is based on the extraterrestrial material researchers have gathered here on earth from meteorites.
[104] Ibid., 1104.
[105] Ibid., 1104.

into the stratosphere, and from this number the team estimated that an asteroid impact could eject as much as a factor of 103 which roughly translates into 1,000 times more debris than the Krakatoa eruption.[106]

The team cannot calculate the exact size of the asteroid based on the Krakatoa eruption, but they can calculate how much more debris from Krakatoa is needed to inhibit photosynthesis. In fact, the team had discovered four ways to calculate the size of the object, and all four calculations are consistent with how much more debris is needed compared to the Krakatoa eruption to stop photosynthesis. Based on all four methods of calculation, the team concluded that the asteroid would have the diameter "10 ± 4km." In conclusion, we do not need to witness an asteroid impact to understand how it negatively impacts the world's land ecosystems, instead we can turn to other documented catastrophic events to draw conclusions about the possible effects of an asteroid impact.

Section 2

The Unobservable: The Asteroid Impact

To continue on the last point made at the end of the above section, all natural sciences in some shape or form deal with some sort of unobservable, whether it is looking at the results from the new LHC for evidence of the Higgs Boson Particle, trying to understand the causes of genetic mutations, or simply pondering the possible causes that may explain why an observable

[106] Ibid., 1105–1106.

phenomenon occurred. The Alvarez team is no different, seeing that they wanted to explain the C-T mass extinctions but they had to do so using unobservable and causal explanations. [107]

This point can be roughly summed up by Lipton's words at the beginning of this chapter: "by [the team] deploying inference to the best explanation [they gained] the advantages of both logical and causal thinking."[108]

From what we have gathered from van Fraassen's position earlier, the Alvarez team cannot justify the C-T extinctions as the direct result of an asteroid impact. Van Fraassen's position, again, is based on the argument that our scientific theories are underdetermined by evidence and should be interpreted as only being empirically adequate. For van Fraassen, as Paul Churchland puts it, the "descriptive excellence at the observational level is the only genuine measure of any theory's truth and one's acceptance of a theory should create no ontological commitments whatever beyond the observational level."[109] It is obvious that no human was around to witness the asteroid impact to assert that the asteroid was indeed the cause for the C-T extinctions. By van Fraassen's concept of empirical adequacy and constructive empiricism, we cannot rule out the supernova explanation nor can we accept any explanation that is not empirically based.

Another possible van Fraassanean type of response to the isotropic evidence in support for the supernova hypothesis is: Whatever method, supporting theory, or evidence used to determine if the isotopic Ir or Pu closely resembles what one might expect from a supernova is highly speculative, as what one considers evidence for supernova isotopic elements is based on what one is willing to accept as evidence in its support. In short, whatever evidence the Alvarez team has

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[107] I am conflating unobservables, as understood in the Philosophy of Science, with unobservable causes here only as a consequence of van Fraassen's empirical adequacy concept. It can be argued that is conflation of unobservables is not justified. However, the true intention of this section is shown how the Alvarez team executed a prime example of the implementation of IBE and that van Fraassen's empirical adequacy fails to doubt the truth of the Alvarez's conclusion.

[108] Lipton, *Inference to the Best Explanation*, 140.

[109] Paul M. Churchland in, "The Ontological Status of Observables: In Praise of the Superempirical Virtues." *Images of Science: Essays on Realism and Empiricism, with a Reply from Bas C. Van Fraassen*, ed. Paul M. Churchland & Clifford A. Hooker. (University of Chicago Press, 1985) 35.

gathered to explain the C-T extinctions may always be dubious to adherents of empirical adequacy, as they can advance the underdetermination of evidence to render the Alvarez's findings questionable. For adherents of empirical adequacy, the asteroid explanation, at best, can only be rationalized as a stance to what caused the C-T extinctions.

A Stance to the Stance?

If we are to take the principle of underdetermination seriously, and alone, then, van Fraassen's empirical stance does follow. However, adopting the empirical stance is implicitly accepting a universal skeptic position, as knowledge is simply reduced to one's opinion, and from here it is quite easy to see how the stance leads to relativism. More explicitly, the empirical stance leads to relativism since there is no criterion to adjudicate true opinion from false opinion. One of van Fraassen's motives for the empirical stance is to reduce scientific explanations to stances. The stance can be envisaged as an attack on IBE seeing that it attempts to doubt its ability to identify the best explanation among the competing pool of explanations. In essence, van Fraassen wants scientific and unscientific explanations to be on equal explanatory footing. As mentioned earlier within this work, there is a problem with suggesting that there is no objective criterion to adjudicate scientific explanations as true, false, or probable. For example, if we reduce scientific explanations to stances (or opinions) it becomes very problematic because scientific explanations become more of an opinion than true descriptions of reality. Better yet, if we cannot identify which stance is the better stance, we run into the problem of there being a stance to the stance. For example, if there is no justification to believe any stance is true due to the principle of underdetermination, all stances become equal in their explanatory ability as implied by van Fraassen.

The above problem is that we get into an infinite regress of stances if there is no means to adjudicate their epistemological standing. IBE, as discussed in this work, is about identifying the explanation that encompasses multiple or a cluster of virtues, and the explanation that entails a cluster of virtues is not just coincidental. In not so many words then, van Fraassen tries to undercut the virtues by claiming they are subjective concepts thus suggesting they are poor criteria to justify any explanation or hypothesis is true to advance his stance position. However, the stance is only an illusion when one comes to see that it leads to an infinite regress of stances. In sum, van Fraassen's stance leads to universal skepticism, and to advance that the empirical stance is the better means to describe scientific explanations is false.

The last sentence needs to be qualified, so here is the rationale to give it justification. Again, we will be looking at the Alvarez example. The asteroid hypothesis is the better explanation compared to the other competing explanations due to the fact that it demonstrates a cluster class of epistemic virtues: The asteroid impact accounts for the Ir found in the C-T boundary line and why the found Ir has the isotopic properties it does, and it also suggests that asteroids are more frequent occurring around our sun than a supernova. The asteroid explanation also tells us that the debris expelled into the stratosphere, by the impact, inhibited photosynthesis thus disrupting the world's terrestrial ecosystems. In short, the asteroid explanation unifies all the evidence to one single cause for the C-T extinctions. And if we are to assert that the asteroid explanation is just a stance, one needs to explain away all the evidence in its support to suggest why it is just a stance. It is not enough to take the universal skeptical position against virtuous explanations.

To conclude this chapter, van Fraassen's stance position is problematic based on the fact that it leads to an infinite regress of stances. But more importantly, taking the stance approach does not explain away the virtuousness of a best explanation. To question or doubt the best explanation, showing why its evidence is problematic should do it. In addition, taking any sort of universal skeptical position against virtuous explanations is counterproductive because it does not illustrate why the best explanation falls short of its title. Instead it advocates an attitude that describes knowledge as something that is out of our reach. One last point: The asteroid impact hypothesis cannot simply be labeled the best explanation because it is the result of a contrastive analysis. Instead, it is the best explanation seeing that it displays a cluster class of virtues thus unifying all the evidence to one singular cause. In sum, all the other competing explanations for the C-T mass extinction, aside from the asteroid impact, do not unify all the evidence to one causal explanation.

Chapter 5

Optimism in Methodological Skepticism

"It is not wisdom to ignore evidence."

David N. Stamos[110]

This chapter will be broken down into three sections: methodological skepticism, the implications of this thesis, and its conclusion. Before we embark on this first section of this chapter, let us revisit the definition of *methodological skepticism*. It was defined earlier as: "[doubting] the truth of scientific hypotheses based on their lack of epistemic virtue when contrasted with other competing hypotheses for the same phenomena."[111] In sum, methodological skepticism is systematic doubt, not in the Cartesian sense, but in the scientific sense.

Section 1

Methodological Skepticism

Scientific doubt has everything to do with the evaluation of the physical evidence and how that evidence then demonstrates the virtuousness of the best explanation. How do scientists evaluate

[110] David N. Stamos, *The Myth of Universal Human Rights: Its Origin, History, & Explanation, Along with a More Humane Way* (Boulder: Paradigm Publishers, 2014) 54.
[111] Introduction, pg.4.

evidence used to support any given explanation? This question has been implicitly asked and answered throughout this work, and it is now time to be explicit. Inference to the best explanation involves methodological skepticism, seeing that it involves the process of eliminating live-option explanations based on their inability to fully explain why something is or is not the case. This point was theoretically demonstrated via the robust version of IBE advocated in this work and exemplified by the Alvarez paper.

There is an assumption granted within methodological skepticism: more often than not, there is one better explanation compared to the others based on evidence. And the way we acknowledge the better explanation is by identifying the explanation that entails a cluster of epistemic virtues and values. Moreover, there is optimism in methodological skepticism, i.e., it allows for knowledge to be obtainable. But more importantly, it gives us a method for how to systematically doubt competing explanations. It is being argued here that systematic doubt occurs when one contrasts all (or at least as many conceivable) live-option explanations in order to identify the best explanation. Once the best explanation is identified, it becomes doubtful that the other explanations are true. Skepticism, in this light, is warranted seeing that it identifies why the other explanations are not adequate to explain why something is or is not the case based on lack of epistemic virtue and value. In short, methodological skepticism is productive skepticism, as it gives us a means to rule out less likely explanations and reveal the best explanation. Again, the best explanation is defined as the one that best displays a cluster of epistemic virtues.

As mentioned earlier, there are scientific examples where there may be explanations that display a cluster of epistemic virtues. For example, there is good evidence to suggest that light behaves like a particle under certain circumstances and in others like a wave. In sum, can we maintain that we know nothing of the nature of light? The answer is *no*, as there is evidence to suggest under certain circumstances light behaves like a particle and like a wave.[112] Maintaining any type of universal skeptical position toward scientific explanations is unwarranted, especially those explanations that explain phenomena with some degree of predictive accuracy. Moreover, in circumstances where there is no or little satisfactory evidence to support an explanation still does not warrant any universal type of skeptical position towards it, and it is precisely this point that demarcates the difference between claiming that knowledge is unattainable versus claiming there is a phenomenon where we know nothing of its cause. More concisely, taking a universal skeptical stance towards knowledge is unwarranted, especially towards those knowledge claims that are derived from a fair contrastive analysis that display a cluster class of epistemic virtues and values.

To conclude this section, methodological skepticism doubts the truth of those explanations that do not measure up against the best explanation. Methodological skepticism is productive, as it does not endorse the position that knowledge is unattainable; rather, it describes why certain explanations are better than others based on how well they elucidate phenomena. Moreover, methodological skepticism encourages wisdom, in that by that taking the epistemic virtues and values seriously it will lead us to more robust explanations.

Section 2

Implications of this Work

There are two sorts of implications that will be discussed within this section. The first implication is directly related to scientific realism. Scientific realism extends beyond the discussion of unobservables; in that what is real in science are those observable/unobservable entities and causes

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[112] This example is one of many possible examples. One could also insert a hypothetical example here as well. The point of this example is to illustrate that there may be an equal number of virtues to explain a phenomena. More important, in such cases taking a universal skeptical stance to such cases is not warranted, as there is still evidence to elucidate the phenomena. This point was previously mentioned in chapter 3.

that explain why something is the case versus not the case.[113] More to the point, scientific explanations (regardless of their observable or unobservable content) that are reached via the method of IBE should be interpreted realistically, a point discussed throughout this work by illustrating why scientific explanations reached via the method of IBE are no miracle. The second implication is the idea that IBE can be used as a general method to obtain and justify general knowledge claims. This last point is now our topic of discussion.

Before it is explained how the method of IBE can be used to obtain and give credence to general knowledge claims, we need to look at the contrastive process more closely. Perhaps the best way to proceed on this point is to ask the question: Why does the contrastive process work so well at identifying the best explanation? Inference to the best explanation works, as a method to obtain knowledge, because it considers all possible live option explanations that may possibly account for a given phenomenon. Moreover, it is rational to assume that not all possible explanations for a given phenomenon can be true because of inconsistencies and contradictions between them, so we identify the best explanation by contrasting all live option explanations until the best explanation emerges. This point will now be made explicit.

The contrastive process is effective at identifying the *best explanation*: it considers and places all live option explanations on equal explanatory footing. Later, by cross-examining each possible explanation, one that best describes the phenomena arises. In short, the method of IBE can be used as a general method to justify and gain knowledge, as it tries to identify the best explanation by filtering-out less probable explanations. To respond to van Fraassen, and the universal skeptics, by cross-examining explanations we are able to track and conceptualize why one explanation falls short while another does not. The advantage of the contrastive process is that it can be applied to investigate all sorts of why-questions. Through the exercise of pondering possible explanations to a

[113] It is perfectly legitimate to speak of causes as real within the realist debate because causes can answer why-questions.

why-question, one is effectively conceiving of possible explanations to answer why something is or is not the case. As a direct response to van Fraassen's critique against scientific why-questions, if none of the lot of explanations can satisfactorily answer the why-question, this suggests that not all live option explanations have been explored. To find the best explanation is to conceive of explanations that may explain why something is or is not the case. To further respond to van Fraassen, scientists do not favour scientific questions over unscientific ones. Instead, they favour scientific based questions because if answered they explain more. More often than not, it just happens to be that trying to answer scientific-like questions leads to more robust explanations.

To vindicate the last point, van Fraassen and the universal skeptics could throw the epistemic virtues into question. Here is a way they may achieve their goal: they may claim that the virtues are subjective concepts versus objective, or that the virtues are context/person dependent. However, this line of reasoning does really not put the epistemic virtues into question, and let us now consider why.

The virtues may begin as subjective, but out of this subjectivity comes objectivity as explained by McMullin: scientists may have their own interpretation of the epistemic virtues; however, by cross-examining live option explanations, scientists actually start to define the virtues in accordance with one another's use. This last point needs to be qualified by an explanation: Scientists do not necessarily always agree on what makes an explanation the best, and some scientists may be sympathetic towards some explanations over others. However, the contrastive process aids scientists in exposing each other's individual use of terms and biases. Exposing and addressing each other's use of terms, and personal biases, forces scientists to remedy them by finding ways to be more objective so that what they do is not merely inter subjective. (The idea is that scientist's eventually come to fine tune their terms which become more narrow and concise to explain their subject matter. Moreover, with time scientists start to make more and better predictions, which is what they expect in a good theory.)

In conclusion, methodological skepticism expresses doubt about those explanations that do not adequately explain a phenomenon, and it is able to do this through contrasting multiple explanations until the best explanation emerges. Moreover, explanations that are the end result of a fair contrastive process demonstrate why they are the best explanation and that it is not a coincidence. As a result, best explanations are to be at least interpreted realistically. As for the universal skeptics, IBE can be used to answer why-questions with some level of accuracy and probability. It is not enough for universal skeptics to suggest that nothing can be known with certainty. The onus should be placed on them to explain why virtuous explanations happen to be the ones that explain more.

Section 3

Conclusion

The purpose of this work is not to demonstrate that IBE is the answer to overcoming universal skepticism, or that the method of IBE renders true conclusions for scientific and non-scientific questions alike. I wanted to demonstrate that universal skepticism, in its many guises, is problematic in maintaining that objective knowledge is out of reach. The more specific intent of this work is to illustrate that knowledge is something that is obtainable, and that the method of IBE is arguably a good method for knowledge acquisition. Perhaps the most important point of this work is that it is not enough to advance universal skepticism, in whatever form, to render scientific explanations questionable. To illustrate the uncertainty of any scientific explanation, it must be done by indicating why the physical evidence or supporting explanations in its support is not sufficient to warrant its epistemological standing. Van Fraassen's works were chosen not only for being akin to universal skepticism, but because he advanced powerful arguments for why scientific explanations may simply just be empirically adequate or stances rather than true. Other skeptics of science have simply tried to devalue science by pointing to theoretical issues, and shortcomings, of one science in order to render all of science and its ability to obtain true explanations questionable. But it is irrational to draw conclusions from a few particulars, and when this line of reasoning is used to critique science it is irrational. To critique scientific explanations, it must be done on a vast case-to-case basis and by evaluating the evidence that is used to justify its explanations.

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