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UNIVERSITY OF CALIFORNIA, SAN DIEGO

Baconian Foundationalism and the Problem of Certainty

A dissertation submitted in partial satisfaction of the
requirements for the degree
Doctor of Philosophy

in

Philosophy

by

Daniel Schwartz

Committee in charge:

Professor Donald Rutherford, Chair
Professor Craig Callender
Professor Tal Golan
Professor Samuel Rickless
Professor Robert Westman

2014

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Chair

University of California, San Diego

2014

EPIGRAPH

[Bacon] is usually considered, not only as having asserted some general principles, but laid down the special rules of scientific investigation; as not only one of the Founders, but the supreme Legislator of the modern Republic of Science; not only the Hercules who slew the monsters that obstructed the earlier traveler, but the Solon who established a Constitution fitted for all future time.

-William Whewell

TABLE OF CONTENTS

Signature Page	iii
Epigraph	iv
Table of Contents	v
List of Figures	vi
List of Tables	vii
Acknowledgements	viii
Vita	ix
Abstract of the Dissertation	x
Chapter 1 Introduction	1
1.1 The <i>Instauratio</i>	6
1.2 Outline of the Dissertation	10
Chapter 2 The <i>What</i> and the <i>Where</i> of Certainty in the <i>Instauratio</i> . . .	15
2.1 Kinds of Certainty	16
2.2 Bacon and the Skeptics	21
2.3 The Certainty of Part Six	27
2.3.1 Arguments for Restricting Certainty to Part Six .	27
2.3.2 Goals and Terminology of Baconian Science . . .	30
2.3.3 The Certainty of Rules as Non-Epistemic	41
Chapter 3 The Certainty of Sense-Perception	47
3.1 What are the Immediate Objects of Sense-perception? . .	50
3.1.1 Ancient Views	51
3.1.2 Bacon's View	57
3.2 What is the Relationship Between Reason and Sense- perception?	60
3.2.1 Ancient Views	60
3.2.2 Bacon's View	61
3.3 What is the Epistemological Status of the Reports of Sense-perception?	65
3.3.1 Ancient Views	65
3.3.2 Bacon's View	68
3.4 What are the Consequences of Withholding Assent to the Reports of Sense-perception?	75

	3.4.1	Ancient Views	76
	3.4.2	Bacon's View	78
	3.5	Conclusion	80
Chapter 4		Baconian Natural History and Scientific Progress	82
	4.1	What is a Baconian Natural History?	86
	4.2	The Unity of Discovery and Justification	93
	4.2.1	The Scholastics' Discovery-Justification Distinction	93
	4.2.2	Evidence that Bacon Rejects the Distinction	97
	4.3	First-Level Notions	103
	4.3.1	Which Notions are First-Level?	106
	4.3.2	Gradualism and First-level Notions	109
	4.3.3	The Nature and Justificatory Force of the Ab- straction of First-level Notions	113
	4.4	The Initial Justification of Natural History	117
	4.5	Scaffolding and Revision Mechanisms	122
	4.5.1	Degrees of Certainty	123
	4.5.2	Enhancement	126
	4.5.3	Self-Correction	132
	4.6	Objections and Replies	134
	4.6.1	Problem Cases for Discovery-Justification Unity	135
	4.6.2	Two More Problems for Revision Mechanisms	140
	4.7	Conclusion	142
	4.8	Acknowledgements	143
Chapter 5		Induction	144
	5.1	Rival Interpretations and Assessments	149
	5.1.1	Gaukroger	149
	5.1.2	Jardine	159
	5.1.3	Urbach	165
	5.1.4	McCaskey	170
	5.2	A New Interpretation of Bacon's Method	177
	5.2.1	Destruction and a New Beginning	179
	5.2.2	Elimination and the First Vintage	182
	5.2.3	Prerogative Instances	189
	5.3	Crucial Instances	197
	5.3.1	General Observations about Crucial Instances	198
	5.3.2	Examples of Certain, Affirmative Crucial Instances	201
	5.3.3	The Reliance on Background Knowledge and Aux- iliary Assumptions	204
	5.3.4	The Exhaustiveness of the Alternatives	207
	5.3.5	Reasoning Affirmatively vs. Reasoning Negatively	209
	5.4	Overview and Conclusion	214

Chapter 6	Conclusion	216
6.1	A Proposed Revision to Bacon’s Method	218
6.2	Case Studies	224
6.2.1	Newton’s Optics	224
6.2.2	Robert Hooke’s Crucial Experiments	235
6.3	Summary of the Dissertation	243
Appendix A	Guide to the Prerogative Instances	249
A.1	Informative Instances	250
A.1.1	Instances of the Lamp	250
A.1.2	Instances Informative to the Intellect	252
A.2	Instances Primarily Directed Towards Operation and Prac- tice: Practical Instances	258
A.2.1	Instances with a Preparative Function (in the cre- ation of a natural history) <i>and</i> Inductive Func- tion: Propitious Instances or Benevolent Instances	258
A.2.2	Practical Instances With a Primarily Inductive Function: Mathematical Instances or Instances of Measure	259
Bibliography		261

LIST OF FIGURES

Figure 4.1: The Order of Discovery and the Structure of Justification . . .	84
Figure 5.1: The Stages of Baconian Induction	178
Figure 6.1: Inverted Prisms	227
Figure 6.2: Newton's Crucial Experiment	229
Figure 6.3: The Detection of Stellar Parallax	240

LIST OF TABLES

Table 4.1: Literate Experience	128
Table 5.1: The Degree of Certainty of Axioms as a Function of the Completeness and Degree of Certainty of a Natural History	146

ACKNOWLEDGEMENTS

I would like to acknowledge the support of Donald Rutherford as the chair of my committee. This dissertation is the end result of a very Baconian process of revision and self-correction, and much of that transformation is the result of his gentle poking and prodding over the course of many drafts. I would also like to acknowledge Samuel Rickless for his attention to detail and his help with my eliminating some inconsistencies that were present in earlier drafts, as well as the whole UCSD History of Philosophy Roundtable for tolerating early drafts of my work and providing helpful feedback.

Chapter 4, in part, significantly reproduces material that has been published in *The Journal of Early Modern Studies* (Volume 3, Issue 1) in the form of an article titled “Is Baconian Natural History Theory-Laden?” The dissertation author is the sole author of that article. I would, however, like to acknowledge the helpful comments of Donald Rutherford as well as two anonymous reviewers. Their feedback on that article resulted in many improvements that made their way into Chapter 4 of this dissertation.

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PUBLICATIONS

Daniel Schwartz, "Is Baconian Natural History Theory-Laden?", *Journal of Early Modern Studies*, Volume 3, Issue 1, Spring 2014.

ABSTRACT OF THE DISSERTATION

Baconian Foundationalism and the Problem of Certainty

by

Daniel Schwartz

Doctor of Philosophy in Philosophy

University of California, San Diego, 2014

Professor Donald Rutherford, Chair

Francis Bacon is one of the architects of the modern conception of scientific method. Yet Bacon's corpus remains little studied and poorly understood. My dissertation is an account of his method with a focus on his reasons for believing that it enables us to acquire knowledge of the nature of things (i.e., of forms) and thereby to establish causal claims with epistemic certainty. It thus has both an interpretive and an evaluative dimension. By way of a new interpretation of Bacon's method, I defend him against those who have too casually dismissed his aspirations to certainty as a result of their reading him through deductivist or falsificationist lenses.

I reconstruct Bacon's method beginning with its foundation in sense-perception. I argue that Bacon (despite his remarks on the faults of the senses,

which other interpreters have overemphasized) takes the side of the Epicureans against ancient skeptics. He holds that all sense-perceptions are true, by which he means that they always causally register mind-independent objects. I then argue that Bacon's aspirations for certainty in natural history hinge on his moderate empiricist foundationalism. Part of his account is an original analysis of the self-correcting character of science, according to which erroneous instances in a natural history are eliminated over time as a result of their conflicting with conclusions overwhelmingly supported by the rest of the instances. The guarantee that sporadic errors can be corrected in time is an important element in being able to secure certainty about forms. The culmination of my interpretation is a discussion of Baconian induction, which is usually understood in deductivist terms as a form of eliminative induction. I argue for an alternative interpretation which emphasizes the non-eliminative role of Bacon's prerogative instances.

Although the method that I describe should be subjected to further scrutiny, not even Bacon believed that he had the last word to say on scientific methodology; he viewed his method as an inductive discovery which would have to be revised. Accordingly, I offer Bacon's method as a promising approach which contains within itself the resources to further expand its heuristic and justificatory power.

Chapter 1

Introduction

Francis Bacon nourished grand hopes for the future of science. He devoted his intellectual life to the design and the partial completion of a six-part *Instauratio magna* or Great Renewal of the sciences. It carved the sciences up, identified deficiencies, and set down a new method in order to “throw open the doors to [nature’s] inner sanctum” and lead us to “certain and ostensive knowledge” in the sciences and a corresponding explosion of technological progress.¹ The method was to be “a form of induction which will unbind experience and separate it out, and reach necessary conclusions by proper exclusions and rejections.”² In today’s era of epistemological humility, scholars looking back on Bacon have been tempted either to attack him for the *hubris* of thinking that scientific induction could ever provide us with epistemic certainty³ or to defend him against these attacks by reinterpreting him as more of a Popperian, more of a fallibilist, more of a skeptic, or, in short, as more of a modern.

This division of opinion is not surprising. After all, one standard textbook definition of induction is that it is a method of reasoning in which the premises

¹I will generally cite the *Novum organum* by book and aphorism number, but I will cite line numbers from the Rees edition for the preliminary remarks and longer aphorisms. Bacon, *The Instauratio magna Part II: Novum organum and Associated Texts*: Preface, D3^v 10.

²Ibid.: *Distributio operis*, B4^v 1-3. Subsequent citations of the *Distributio operis* will be to this same edition.

³Hereafter, whenever I use the term ‘certainty’ by itself, I mean epistemic certainty. When I refer to other kinds of certainty, such as psychological certainty or moral certainty, I will include those qualifiers. I will discuss these distinctions in 2.1.

render the conclusion probable, but do not entail it. Ian Hacking, for instance, says in a definition intended for newcomers to inductive logic that the method “analyzes risky arguments using probability ideas,”⁴ and he contrasts this risk with the safety of deduction. “If an inference is inductive,” according to Peter Lipton, “then by definition it is underdetermined by the evidence and the rules of deduction.”⁵ While the evidence combined with some proposed rules for induction might entail a particular conclusion, philosophers generally hold that the rules of induction (e.g., the principle of uniformity) are themselves risky. Even John Norton, an arch defender of certainty in science, claims that an inference is inductive when the “evidence lends support to a hypothesis, in whatever degree, while not establishing it with deductive certainty.”⁶ Norton leaves room for inductive certainty, but this peculiar kind of certainty is not completely safe. Since the conclusion is never guaranteed at the level of deductive certainty, “there is always inductive risk.”⁷ Given this constant, often definitional linkage of induction with risk, it is not surprising that philosophers would tend to think that no philosopher worth his salt would hold that induction is capable of guaranteeing real certainty.

Note that the conventional view is not that induction is risky while deduction is risk-free. Deductive arguments are subject to risk too; if either the premises are false or the logical form is invalid, then they are unsound and do not reliably establish the conclusion. The thought, then, is that induction and deduction differ in the locus of risk. In inductive arguments, the inference from the evidence to the conclusion is risky; in deductive arguments the risk stems from the possibility of false premises or lapses in logical form. To put it another way, even the strongest inductive arguments are not truth-preserving, whereas valid deductive arguments are.

In accordance with this conventional wisdom about the riskiness of induction, one group of scholars—probably the majority—understands Bacon as claiming that his method is capable of arriving at certainty, but they judge that he fails

⁴Hacking, *An Introduction to Probability and Inductive Logic*: p. 18.

⁵Lipton, *Inference to the Best Explanation*: p. 7.

⁶Norton, “A Little Survey of Induction”: p. 2.

⁷*Ibid.*: p. 4.

to explain how this aspiration can be realized. Lisa Jardine, for example, states that Bacon's goal is to go beyond the moral certainty of Descartes, that "it is that absolute necessity [of metaphysics] which [Bacon] sets himself unequivocally (albeit only notionally) as the goal of his scientific method."⁸ But, Jardine continues, Bacon's "philosophical failure" consists in the fact that he cannot bridge the gap "between the merely highly confirmed (physics), and the certainty of *scientia*."⁹ L. Jonathan Cohen agrees and explains why this is the case: "Bacon was wrong to suppose that his method could even in the end produce conclusively certain results. His mistake here sprang from a failure to recognize that in eliminative induction every prior assumption about the variety of hypotheses that are open to elimination is itself empirically corrigible."¹⁰ Barbara Shapiro notes that this failure led subsequent philosophers and scientists—even those influenced by Bacon—to abandon the ideal of absolute certainty: "But how much was enough to move uncertain or probable conjecture into the realm of 'true theories' or 'certain axioms'?" The method outlined in Book II of Bacon's *New Organon* did not provide the answer to what has always been one of the most vexing problems for philosophers of science."¹¹ What is common to these objections is the accusation that Bacon ignores an epistemic gap between evidence and inductive generalizations and that his method of eliminative induction fares no better than other modes of induction in trying to bridge that gap without the introduction of any risk of error.

Meanwhile, Bacon's defenders on this point agree that he would be naive if he thought his method of induction capable of proving anything with certainty.

⁸Jardine, "*Experientia Literata* or *Novum Organum*? The Dilemma of Bacon's Scientific Method": p. 58.

⁹Ibid.: pp. 60-1. It is important to clarify the sense of necessity in which it is related to certainty. If a conclusion is certain, then perhaps one must be able to show, or show beyond a reasonable doubt, that: Necessarily (If the grounds for the conclusion are true, then the conclusion is true) and that the grounds or premises are true. But it does not follow that the conclusion should be regarded as necessary *simpliciter* unless the grounds are necessary as well.

¹⁰Cohen, "Some Historical Remarks on the Baconian Conception of Probability": p. 222.

¹¹Shapiro, *Probability and Certainty in Seventeenth-Century England*: p. 25. Silvia Manzo similarly writes: "Bacon's project suggests in theory that the obtaining of absolute certain knowledge is possible but in fact such knowledge is revealed to be impossible [...] a gap emerges between the proposed goal of science and the ways to reach it: Bacon tried to obtain absolute certainty but he only could arrive at degrees of certainty and probability both in theories and in facts." Manzo, "Probability, Certainty, and Facts in Francis Bacon's Natural Histories. A Double Attitude Towards Skepticism": p. 137.

Luckily for Bacon's reputation, they say, that just isn't the case; all Bacon means when he discusses certainty is that the empirical data can render a conclusion so likely that we can be confident that it is true for all practical purposes. Peter Urbach is a representative example here. Bacon, he says, "never described the axioms delivered by his method as infallible, merely as 'certain' or 'proved' or 'demonstrated', none of which terms seems to have carried the connotation of necessary or necessarily true."¹² All Bacon means, he continues, is that after enough proofs a thesis can become "so convincing that it is considered practically certain." Like Urbach, Silvia Manzo claims that Bacon's idea of certainty is closer to the modern concept of moral certainty than to mathematical and absolute certainty. However, Manzo appears to mean that Bacon has moral certainty in mind in practice but not in theory. That is, he has one kind of certainty in mind when writing as a philosopher but another kind in mind when he gets down to hard science.¹³ Stephen Gaukroger agrees that certainty is not Bacon's goal. Bacon, he says, is more concerned with progress than with certainty. He "is not concerned so much with the degree of certainty of results in natural philosophy (he has no time for skepticism in this regard, for example), but in making natural philosophy informative and productive."¹⁴

Contrary to Urbach and Gaukroger, I will show that Bacon is indeed concerned with certainty and that he believes that science can ultimately arrive at a body of epistemically certain ideas and beliefs concerning causes. So far, I am in the camp of Lisa Jardine and L. Jonathan Cohen. But neither Jardine, Cohen, nor anyone else has yet dug deeply enough into the reasons for Bacon's optimism, and until we do so, it is premature to pass judgment. By providing a new interpretation of Bacon's scientific method, I aim to defend Bacon against the charge of naiveté and show that there are features of his method that anticipate and are designed to address some of objections typically leveled against his aspiration to

¹²Urbach, *Francis Bacon's Philosophy of Science: An Account and a Reappraisal*: pp. 188-9. Here again it is important to bear in mind the sense of "necessity" in which it is related to "certainty." See n. 9 above.

¹³Manzo, "Probability, Certainty, and Facts in Francis Bacon's Natural Histories. A Double Attitude Towards Skepticism": p. 128.

¹⁴Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy*: p. 159.

certainty. Since the objections all revolve around his supposed inability to bridge a gap between evidence and epistemically certain causal claims, I must examine Bacon's account of (1) the nature of the evidence on which knowledge of causes is to be based, (2) the method of justifying causal claims on the basis of that evidence, and (3) the nature of the certainty that Bacon aims for. My central argument is that Bacon aims for a standard akin to justification beyond a reasonable doubt, not for demonstrations of metaphysical necessity (Chapter 2); that his ultimate source of evidence is sense-perception and that he offers a promising defense of the reliability of sense-perception against skeptical attacks (Chapter 3); that on this basis he uses a method that conforms to a foundationalist structure while also promoting revision and self-correction, so that the degree of certainty throughout will tend to be augmented over time (Chapter 4); and that the characterization of the inductive stage of the method as eliminative, while accurate in some respects, glosses over or obscures important non-eliminative features, the most important of these being crucial instances (which themselves have wrongly been cast in an eliminative mold by Bacon's readers), and that these non-eliminative features of Baconian induction better explain Bacon's epistemic ambitions because, in conjunction with Bacon's foundationalism, they can be used to try to avoid problems of underdetermination (Chapter 5).

My defense of Bacon will be qualified in two significant ways. First, the most charitable reading of Bacon takes him (as I said) to aim for justification beyond a reasonable doubt. This is a significant kind of epistemic certainty, but it is a conception of certainty which leaves open the logical possibility of epistemically certain beliefs that are in fact false. Second, as is well-known, it is rare that a scientific law can be stated in the form of a truly exceptionless generalization. As I discuss in Chapter 6, I think Bacon does aspire, and is wrong to aspire, to certainty about exceptionless laws ("rules of operation," in more Baconian terms), but my hope (not to be realized within this dissertation) is that his method can be supplemented with a satisfactory account of *ceteris paribus* laws, or laws that include a *proviso* that other things or confounding factors are held equal or excluded from consideration.

The purpose of evaluating Bacon’s view, as I see it, is to learn from it, to find value in Bacon’s account where it shows promise and to learn what pitfalls to avoid when we see him stumble. Learning from Bacon in this way requires first and foremost a close reading of his work and careful exegesis. In the remainder of this introductory chapter, I will situate the texts with which I will be most concerned within their context in the *Instauratio* and then outline in more detail the plan for the rest of the dissertation.

1.1 The *Instauratio*

Aside from a handful of Bacon scholars, most readers of Bacon examine only one of his works, the *Novum organum*, and most of them stop reading after the discussion of heat at the start of Book Two. Certainly the *Novum organum* is Bacon’s crowning achievement, but a full appreciation of his method and of the place of certainty in it requires that one read more widely than this. Since I will be drawing my evidence from throughout Bacon’s philosophical writings, readers may find the following survey of his *Instauratio* helpful. Note, though, that some of Bacon’s philosophical writings, such as the *Essays*, *De sapientia veterum*, and the *New Atlantis* were not intended to be part of the *Instauratio* at all.

Bacon first conceived of the idea of a six-part *Instauratio* circa 1607-1612. Originally, there was to have been one book devoted to each of six parts.¹⁵ But in composing an early version of the natural historical part, the *Phenomena universi*, it seems he quickly found that, while a single book might suffice for the first couple of parts, multiple volumes would be necessary for those that dealt with natural science proper. Beginning with the *Descriptio globi intellectualis* of about 1612, therefore, he would refer to the six *parts* of his *Instauratio*.¹⁶ I will discuss them in order.

¹⁵ “Three books (*libri*)—the third, the fourth, and the sixth—have been allotted to the Interpretation of Nature itself.” *Partis instaurationis secund delineatio argumentum* in Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 3, p. 547, my translation.

¹⁶ “*tertiam Instaurationis nostrae partem.*” *Descriptio globi intellectualis* in Bacon, *Philosophical Studies, c. 1611- c. 1619*: D8^v 3. In the overview that follows, I will mainly consider the structure of the *Instauratio* as Bacon saw it from 1620 onward; I will ignore any differences from his earlier conception of that structure (in my view there are none of any great importance).

Partitions of the Sciences This first part surveys what is already known and organizes it into a hierarchical classificatory structure. In the course of this survey, it identifies areas of inquiry which have been neglected or which are deficient.¹⁷ We know that Bacon wrote both *The Advancement of Learning* and the revised Latin version *De augmentis scientiarum* to fulfill this function. The *Descriptio globi intellectualis*, which was written several years after the *Advancement* but still well before the *De augmentis* seems to be an abortive attempt at the Latin version and, like those other two works, offers a partition of the sciences—a description of the intellectual globe. However, after making a number of partitions in that work, he turns to the deficiencies within natural history in particular and offers an extended example of how one should go about filling in the gaps in natural histories of heavenly objects. For that reason the *Descriptio globi intellectualis* could also be considered an early natural history.

Novum Organum The second part sets down the method of induction, called the “interpretation of nature,” which is to be used in the third and fourth parts.¹⁸ The *Novum organum* satisfies this function, but the work is unfinished. (Bacon decided that it was more important to illustrate his method with examples, lest his intent not be fully grasped, than to finish setting down the method itself.¹⁹) We have an abstract of the second part, the *Partis instaurationis secund delineatio argumentum*, which was found among Bacon’s papers and published posthumously. It seems to have been written some years before the *Novum organum* (perhaps as early as 1607), as evidenced by the fact that it refers to six books, rather than six parts, of the *Instauration*, but it does give us some idea of Bacon’s plans for the remainder of the work. Bacon’s still earlier work (perhaps completed by 1603) *Valerius Terminus of the interpretation of nature* also anticipates much of the material in the *Novum organum*.

¹⁷ *Distributio operis*, B2^v 1.

¹⁸ *Ibid.*: B3^r 25.

¹⁹ “And what if one such [solid, steadfast] intellect were to appropriate the plan and purpose of my *Organum* and put it to the test? He still does not know how to proceed[...][M]y *Organum*, even if it were finished, would not carry forward the Instauration of the Sciences much without Natural History, whereas Natural History without the *Organum* would advance it not a little.” Bacon, *The Instauration magna: Part III: Historia naturalis*: B7^r- B8^v.

Natural History The third part, on the “phenomena of the universe,” assembles observations and experiments regarding each topic of inquiry in the natural world. Bacon completed a preface to this part, as well as a *History of the Winds* (*Historia ventorum*), a *History of Life and Death* (*Historia vitae et mortis*), and a *History of Dense and Rare* (the *Historia densi et rari*, which is a revised version of his earlier *Phenomena universi*). Earlier in his career, Bacon also completed a history of sound and hearing. Note, however, that in a letter to Father Fulgentio in 1625 Bacon states that his own attempts at natural history are impure, in that they include elements that would properly belong to the fourth part.²⁰ We will see in Chapter 4 that he believes that this impurity is necessary in the early stages of natural history. Towards the end of his life, he wrote the *Sylva sylvarum*, which is even more preliminary, for it is, more or less, a grab bag of observations on a wide variety of subjects. However, because of its preliminary status, it is a good source of examples of Bacon’s method of literate experience, which has an important role in the generation of reliable natural histories.

Ladder of the Intellect The fourth part offers examples of the method of induction as it goes to work on the material gathered in Part Three. The purpose of the examples is to illustrate the whole process of inquiry, not just certain self-contained points.²¹ We have what seems to be an early attempt at a preface to this part, the *Scala intellectus sive filum labyrinthi*, which must have been written before 1612 since it refers to books rather than parts of the *Instauratio*.²² Later, he seems to have replaced it with a different preface, the *Abecedarium novum naturae*, which lists the topics of inquiry for part four.²³ The inquiry into heat in the second book of the *Novum organum* seems to be what Bacon envisaged for this part. We

²⁰Bacon, *The Letters and the Life of Francis Bacon*: Vol. 7, p. 533, n. 2.

²¹*Distributio operis*, C2^v 16.

²²“It is therefore, our purpose, as in the second book (*libro*) we laid down the precepts of genuine and legitimate disquisition, so in this (*hic*), to propound and establish, with reference to the variety of subjects, illustrative examples.” I will use Montagu’s English translation of the *Scala intellectus* unless otherwise specified. Bacon, *The Works of Francis Bacon, Lord Chancellor of England*: Vol. 3, p. 520.

²³“The Abecedarium belongs to Part Four of the *Instauratio*, the part which is the ladder or machine of the intellect. Yet this is not the ladder proper, rather it is as a preparative (*parasceve*) to it.” *Abecedarium novum naturae* in Bacon, *The Instauratio magna: Last Writings*: 24^r 17.

also have some fragments from late in Bacon's life which follow that basic model. These include inquiries into the animate and inanimate, the magnet, and light.

Anticipations of the Philosophy to Come The fifth part contains those discoveries which have been arrived at without employing the proper method of induction. All anticipations (*ante + capio*, or seize beforehand, a translation of the Greek *prolepsis*) involve premature claims that something in the world has been grasped by the mind or has been discovered. Usually Bacon criticizes such anticipations, but he reserves a special place within his own philosophy for such premature knowledge claims when they are the product of an earnest effort to avoid the idols, which are false ideas and beliefs stemming from one of a number of causes discussed by Bacon, including (famously) confirmation bias.²⁴ Merely avoiding common causes of error, without the implementation of the proper method of induction, is not enough to ensure certainty, so this part of the *Instauratio* is temporary and uncertain (and the investigator must identify it as such). Bacon completed a preface to this part, *Prodromi Sive Anticipationes Philosophiae Secundae*, and at least some of his early work on natural science, such as the *Thema coeli*, seems to belong to this part as well.

Second Philosophy or Active Science When the work of interpretation is finished with respect to any topic of inquiry, the conclusions are added to the sixth part. In contrast to the fifth part, the sixth is not provisional, but solid and certain. Here the mind “come[s] to rest in causes truly unraveled” and the investigation comes to a close.²⁵ In his letter to Father Fulgentio in 1625, Bacon confesses that he has given up all hope of working on this part but remains hopeful that “the

²⁴“I do not doubt that if anyone, though of moderate gifts but ripe judgement, could and would set aside the Idols of his mind and resolve to undertake the inquiry afresh, and involve himself attentively, diligently, and frankly with the truths of natural history and its accounts, he himself would be able, whoever he is, to penetrate much further into nature by himself using his own innate mental powers and, in short, by his own naked anticipations than by reading all kinds of authors, no end of abstract meditation, or regular and repeated disputations—even if he had not deployed the right machines nor followed the proper form of interpreting.” *Prodromi Sive Anticipationes Philosophiae Secundae* in Bacon, *The Instauratio magna: Last Writings*: R2^v 17-26.

²⁵*Distributio operis*, C3^r 6.

ages and posterity will make it flourish.”²⁶

1.2 Outline of the Dissertation

The *Instauratio*’s structure suggests that certainty might be one of the key desiderata of Part Six. In Chapter 2, I will argue that Bacon indeed intends for the ultimate goal—one that he foresees others achieving, even though he does not expect to achieve it himself—to be a stage at which our ideas and beliefs concerning causes are epistemically certain. To confirm this reading, I will examine Bacon’s critical response to skepticism. However, although epistemic certainty about causes is a feature of Part Six, epistemic certainty about *other* beliefs can be reached prior to Part Six. I will show that the usual focus on Part Six as *the* domain of epistemic certainty in Bacon’s system grows out of a misinterpretation of his discussion in the *Novum organum* of the certainty he desires from his so-called rules of operation, which are to be derived, in Bacon’s view, from our knowledge of formal causes. I argue that in addition to employing a conception of epistemic certainty Bacon also uses the term ‘certainty’ to characterize rules that are exception-free and therefore reliable guides to practice. But it is a mistake to confuse the property of being exceptionless with the property of being justified. Several commentators on Bacon are guilty of this confusion and think that only an exceptionless rule could qualify as epistemically certain. The truth is that these rules can be “certain” in the sense of being exceptionless even if they are not proved to be so and that some of our beliefs can be “certain” in the justificatory sense even if they are not exceptionless rules. Since these exceptionless rules have their home in Part Six, those guilty of this confusion have failed to appreciate the fact that although the conclusions of Part Six must be epistemically certain, epistemic certainty is not restricted to it.

By establishing the possibility of epistemically certain beliefs prior to Part Six, I lay the groundwork for a discussion of the certainty of sense-perception in Chapter 3 and of natural history in Chapter 4. Indeed, since our knowledge of

²⁶Bacon, *The Letters and the Life of Francis Bacon*: Vol. 7, p. 533, n. 2.

formal causes and the corresponding exceptionless rules is ultimately based on sense-perception, Bacon thinks that we cannot attain certainty regarding formal causes unless sense-perception is free of reasonable doubt. Chapter 3 examines this view and assesses whether Bacon can plausibly explain why sense-perception is free of doubt. This is all the more tricky since Bacon often seems to disparage the senses and to point out their shortcomings. I show that Bacon follows the ancient Epicureans in assigning to the evidence of the senses a foundational status. I focus on four theses about sense-perception held by both Bacon and the Epicureans: (1) that the objects of sense-perception are mind-independent, (2) that sense perception is *alogos*, or non-notional and non-propositional, (3) that all sense-perceptions are true (here I argue that Bacon's account of truth is to be cashed out in terms of the sympathy or consent between the sense organs and their objects, meaning that sense-perception causally registers mind-independent objects) and (4) that doubting sense-perception would undermine all knowledge and action. I also offer an account of Bacon's disparagement of sense-perception which is compatible with the above theses. Acts of sense-perception do indeed serve as the occasion for certain kinds of *intellectual* errors, but they are never the cause of errors *per se*.

With the senses as the foundation, the next step in Bacon's philosophical project is to compile a thorough natural history. Chapter 4 shows how history builds on the evidence of sense-perception. The basic picture is a moderate foundationalist one. I define moderate foundationalism as a theory of the structure of the justification of our knowledge which holds that this structure is hierarchical and begins with foundational, strongly justified beliefs. While these beliefs may not be certain initially, Bacon's method of natural history allows for the whole structure to increase in certainty over time. Based on strongly justified basic beliefs, one ascends to more abstract parts of natural history and even to some beliefs about causes, and then, using that more abstract knowledge, one can provide additional justification for, revise, or correct lower level beliefs. So although Bacon's method is sometimes said to shun hypotheses or to strive to be theory-free, we see here an important role for top-down reasoning.

One wrinkle in this picture, in comparison to recent versions of moderate foundationalism, is that important justificatory steps (involving the justification of notions, i.e., abstract ideas) take place prior to the justification of basic beliefs, and these justificatory steps should also be understood from a foundationalist perspective. I explain why Bacon believes that notions themselves require justification and propose that the account of sense-perception in Chapter 2 can make good sense of the claim that sense-perception justifies the notions that we abstract from it.

In Chapter 5, I turn to induction proper in order to examine Bacon's grounds for claiming that his method can establish general causal claims with certainty. I discuss why the standard reading of Bacon as a proponent of eliminative induction is misleading, if by eliminative induction we mean a disjunctive syllogism of the form:

(1.1)

- (1) A, B, C, or D is the cause of (a type of) phenomenon P.
- (2) The hypothesis that A is the cause is falsified by X, the hypothesis that B is the cause is falsified by Y, and the hypothesis that C is the cause is falsified by Z (where X, Y, and Z are observational reports).

∴ (3) D is the cause of phenomenon P.

This syllogism is, of course, valid, but it is difficult to justify the premises. The first premise opens the door to the problem of underdetermination because there may be additional possible causes (E, F, G, etc.) that we have not ruled out. The second premise also opens the door to the problem of underdetermination, this time because a single observational report does not falsify a single hypothesis but only falsifies the whole theory that includes the hypothesis, and there may be other assumptions that we could reject instead of the hypothesis. Among other problems, the syllogism also assumes that P is genuinely a *type* of phenomenon and that the instances of P have not been grouped together despite lacking the same type of cause.

I defend Baconian induction against these avenues of attack by pointing out that although it includes an eliminative stage, the essence of the method lies elsewhere. In the ideal case, Bacon pursues crucial instances that aim to establish the true cause of a phenomenon directly, not by falsifying alternatives. I also show that the eliminative component of the method is more sophisticated than the schema above suggests. For example, Bacon proposes a particular kind of experiment which can help to narrow down the possible causes of a phenomenon and justify something along the lines of the first premise above. (Although crucial instances might enable one to bypass that premise entirely, it is not clear that Bacon believes crucial instances will always be possible, so it is worth thinking about how Bacon might intend to fortify the eliminative component of the method. In addition, crucial instances are not, as Bacon presents them, self-contained, and other types of instances can serve as background knowledge for their proper interpretation.) On the whole, then, a careful examination of Baconian induction reveals that some of the typical objections to it are based on straw men.

The dismantling of straw men is not, of course, a full defense. In the concluding chapter, therefore, I draw on crucial experiments by Isaac Newton and Robert Hooke to show that Bacon's method, as applied by Newton and Hooke, can plausibly establish its results with certainty. However, one revision to Baconian induction is necessary. To safeguard our causal laws, we must attach *ceteris paribus* clauses to them. For example, Newton is able to prove that white light consists in rays of light that have dispositions to be refracted to different degrees. But he is not so rash as to rule out the possibility (for example) that a different kind of white light could one day be discovered. New kinds of white light might provide us with good reason to revise the causal law by making it more accurate or by listing the exception to it explicitly, but the law in its qualified form is nevertheless true. (I admit, though, that *ceteris paribus* laws face difficult challenges of their own and that I cannot respond to those challenges within this dissertation.)

Bacon did not see the need for *ceteris paribus* laws, I argue, because of his principle of limited variety (i.e., his assumption that natural histories would eventually describe the whole range of phenomena in the universe). Bacon imagines

that we will eventually have natural histories so exhaustive that we will be able to rule out the possibility of counterexamples. But the universe is more vast and more complex than Bacon imagined. Here, then, is a genuine shortcoming of Baconian induction. But revising the method by allowing for *ceteris paribus* laws seems promising and can perhaps be justified inductively by means of Baconian induction itself (by drawing on instances in the history of science). Indeed, Bacon himself intends for his method to be revisable in light of the course of science, and given his influence on the history of science, the revisions and corrections that we make to Bacon's method on the basis of that history can be understood as a continuation of Bacon's project rather than a rejection of it.

In many ways, the account of induction that will emerge from this dissertation is more modern than many scholars give Bacon credit for. He has been falsely accused of neglecting the role of hypotheses and of being ignorant of the role of theory in guiding observation. Yet Bacon isn't exactly modern either, and we will sometimes see him argue in ways that might seem foreign to us. I would especially caution against assuming that only deduction is truth-preserving and then concluding, on the basis of the fact that Bacon defends his method inductively, that the argument must be subject to some uncertainty. This assumption would beg the question at issue. Bacon himself notes on occasion that the existing method, since its reliability is up for debate, cannot be used to evaluate his own method, in much the same way as a judge accused of a crime would not be permitted to take on new cases. This is every bit as true today. The idea that induction is riskier than deduction is now on trial, and we must be open to *inductive* arguments that challenge that idea.

Chapter 2

The *What* and the *Where* of Certainty in the *Instauratio*

There is no question that Bacon holds that his method can achieve something that he terms “certainty.” What is unclear is the nature of this certainty. The purpose of the method, as he says in the preface to the *Novum organum*, is to “throw open the doors to [nature’s] inner sanctum” and lead us to “certain and ostensive knowledge” in the sciences.¹ This mention of an “inner sanctum” makes clear that the goal is certainty regarding the nature of things, not merely certainty regarding the way things seem or regarding causal regularities. Likewise, in the *De augmentis*, Bacon stresses that doubt, though useful, is often merely a tool to be used as a means to certainty. It is wrong to hold onto doubts perpetually. Instead, “the legitimate use of reason is to make doubtful things certain and not certain things doubtful.”² Furthermore, Bacon makes hundreds of claims in his natural histories which he describes as “certain” and he also indicates that formal causes, which his method is designed to discover, are somehow related to the need for certainty.³

¹*Distributio operis*, B4^v 1-3.

²Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 4, p. 358. The *De augmentis* translation is split between Volumes 4 and 5 of the edition by Spedding, Ellis, and Heath. Henceforth, I will cite the *De augmentis* translation by the volume and page number in this edition.

³For a discussion of some examples of claims described in the natural histories as “certain,” see 4.4. The exact relationship between forms and certainty is one of the topics discussed in this

I will not begin to examine Bacon’s reasons for thinking that his method is capable of arriving at certainty until Chapter 3. First, it is necessary to determine what he means by the term “certain” and which items of thought, at which stages of the scientific process, can have the property of being certain. My purpose in this chapter is to establish that Bacon affirms the possibility of what we might term epistemic certainty, as opposed to merely psychological or moral certainty, and furthermore that this epistemic certainty is not confined to Baconian metaphysics in the sixth and final part of the *Instauratio*. (There are also different conceptions of epistemic certainty, which I will adjudicate among partly at the end of 2.2 and somewhat more fully in 3.5.)

I will begin in 2.1 by reviewing the three main conceptions of certainty that might be thought to be employed by Bacon: epistemic, moral, and psychological certainty. Then in 2.2, based on an analysis of Bacon’s objections to skepticism, I will show that he is committed to the possibility of epistemic certainty in particular. Although many scholars take this view, they have sometimes looked to Bacon’s discussion of forms and rules of operation for his account of epistemic certainty—and here, as I will argue in 2.3, they are mistaken. The certainty that Bacon requires of rules of operation and which is provided by the knowledge of formal causes is not the same certainty that he insists on when responding to skeptics; indeed, it is not a form of epistemic certainty at all.

2.1 Kinds of Certainty

Certus or “certain” has a wide range of meanings. It can describe what is fixed or settled, someone who is dependable, someone who is sure of something, or something that is proved, just to name some of the more common meanings.⁴ All of these meanings are related in one way or another to the idea of fixity. Someone who is sure of something does not waver, someone who is dependable does not sway from his word, and something that is proved will never be refuted.

We can identify three kinds of certainty: epistemic, moral, and psychologi-

chapter.

⁴“Certus,” Lewis et al., *A Latin Dictionary*.

cal.⁵ These are broad kinds which themselves are amenable to a number of different conceptions, but the basic distinction is between certainty as involving justification (epistemic), certainty as involving a high degree of probability or verisimilitude suitable for the conduct of life (moral), and certainty as strong conviction (psychological).

The idea of epistemic certainty has its origins in the distinction between knowledge and opinion which can be found in some Presocratics, such as Parmenides, and which is prominent in Plato and Aristotle. In the *Meno*, for example, Socrates observes that when we know not only that something is true, but also why it is true, our opinion becomes knowledge and it becomes fixed in place. Plato does not employ the concept of “certainty” here; since anything uncertain is outside the realm of knowledge entirely, the concept would serve no distinct purpose for him. Similarly, Aristotle in the *Posterior Analytics* explains what conditions need to hold for something to be demonstrated. When something is demonstrated, we have a deep understanding of why it *must* be true and cannot be false; before that point, what exists is an opinion. For the ancients, there was no middle probabilistic stage of a demonstration that made talk of “certainty” necessary for the epistemologist. Probability belonged to the realm of opinion and to arguments based on opinions; it was thought to be a feature of dialectical and rhetorical arguments rather than demonstrative ones.⁶

At some point, the Latin *certus* began to be used to refer to the epistemic status of demonstrated truths (or to anything else of the same epistemic status, if for example someone regarded self-evident truths as having just as much justification).⁷ For example, Cicero says of Plato’s dialogues that they argue back

⁵On this threefold division of kinds of certainty, see the *Stanford Encyclopedia of Philosophy* entry (*SEP* henceforth): Reed, “Certainty”. Peter Klein stresses a twofold division between evidential and psychological certainty in Klein, *Certainty: A Refutation of Scepticism*: p. 128. “Moral certainty” would presumably fall under the category of evidential certainty. As Klein notes, some philosophers have referred to the evidential kind of certainty as objective and the psychological kind as subjective.

⁶For a discussion of these issues as they manifest themselves in the philosophy of Aquinas, see Hacking, *An Introduction to Probability and Inductive Logic*: pp. 20-2.

⁷Why and by what stages the vocabulary ultimately changed are interesting questions to which I have no definite answer. Even the emergence of skepticism seems not to have brought the concept of “certainty” into epistemology. Early debates between Epicureans, Stoics, and skeptics of various stripes were couched in terms of the existence or non-existence of knowledge, truth,

and forth without asserting that some conclusion is certain (“*nihil certi dicitur*”).⁸ This is the epistemic sense of certainty. Note that the term ‘epistemic certainty’ is not employed by Bacon or his contemporaries. When they want to talk about this idea, they may use the term “certainty” without any qualification, or they may refer to “absolute” or “metaphysical” certainty, as Descartes sometimes does.⁹

There are a number of possible ways of conceiving of epistemic certainty.¹⁰ As I said, they are all ways of trying to capture what it is about an item of knowledge that makes it justified in some special way. Two possible conceptions include: (1) the *scientia* conception, according to which epistemic certainty consists in the property of being either self-evident or of being shown to follow necessarily from the self-evident,¹¹ and (2) indefeasible justification (which might be thought of as a particularly robust sort of justification beyond a reasonable doubt¹²), meaning

clarity, and apprehension, not in terms of certainty. The Latin *certus* appears to have entered epistemology by the first century B.C., but it appears only occasionally. Lucretius defends the possibility of knowledge, not certainty, against the skeptics; and Cicero, when discussing skepticism, speaks only occasionally in terms of certainty. For the most part, he retains the earlier vocabulary (although this is sometimes obscured in translation). (Adverbial forms of the term are more common in Cicero.)

⁸*Academica* in Cicero, *De Natura Deorum/Academica*: I. 46. In keeping with my account of the Greeks above, I have been unable to find a particular Greek word that was routinely translated by Cicero or others with the Latin *certus*. A bilingual Latin-Greek dictionary from late antiquity (the authorship is not known with certainty but it is ascribed to an unknown Philonexus) suggests translating “*certus*” with the Greek “*alethes*” (true) but “*vera*” is the usual Latin translation for that term. Goetz et al., *Corpus glossariorum latinorum*. See John Glucker’s “*Probabile, Veri Simile*, and Related Terms” in Powell, *Cicero the Philosopher: Twelve Papers* for a discussion of Cicero’s translations of a variety of epistemic terms. It is notable that *certus* and any Greek equivalents are absent from his survey.

⁹See *Principles* IV, art. 206 in Descartes, *The Philosophical Works of Descartes*: Vol. 1, p. 290. For a useful discussion of Descartes’ attitude towards epistemic certainty, see Garber, “Science and Certainty in Descartes”.

¹⁰I won’t say much about those conceptions which seem to me fatally flawed. For example, on a “truth-evaluating” or “unmistakability” sense of certainty, something is certain iff it is guaranteed to be true or if one cannot be mistaken. This would imply that any necessary truths are certain even if we believe them for ridiculous reasons. See Reed, “Certainty” in the *SEP* on Firth’s truth-evaluating conception. Also see Tlumak, “Certainty and Cartesian Method”: pp. 50-1 for a discussion and rejection of the similarly flawed “unmistakability” criterion.

¹¹There are of course different ways one could flesh this out. For example, is something certain if it has been shown to follow from the self-evident, even if one is not currently contemplating the demonstration, or if one has forgotten earlier steps in the demonstration but remembers finding them valid? Descartes answers in the negative and argues that the proof of God’s existence is necessary to ensure that demonstrations may still be trusted even when they are not currently being contemplated.

¹²I use the expression “justification beyond a reasonable doubt” advisedly. As has been dis-

that for every potential defeater, one is justified in believing that it is false. (This indefeasibility conception admits of some further nuancing should one wish to specify whether it considers logically possible, metaphysically possible, or physically possible defeaters.) On the *scientia* conception, certainty implies truth; but on the indefeasible justification conception, it does not.

The term ‘moral certainty’ was coined by the theologian Jean Gerson (1363-1429). For him, it was a level of certainty about what we should do which sufficed to absolve one of sin in case one acted wrongly despite making a conscientious effort to be moral.¹³ Descartes’ definition of moral certainty as certainty that suffices “for application to ordinary life” or for the regulation of our behavior is not too far off from Gerson’s definition, except Descartes’ focus is on the needs of getting by in this world rather than in the next one.¹⁴

The ultimate roots of the idea of “moral certainty” go back still further to a medieval misreading of Aristotle. Medieval scholastics pointed to a passage in Book I of the *Nicomachean Ethics*: “One would speak adequately if one were to attain the clarity [*diasaphethein*] that goes along with the underlying material, for precision [*akribēs*, sometimes translated as “exactness”] ought not to be sought in the same way in all kinds of discourse.”¹⁵ Because they sometimes mistranslated *akribeia* as certainty, they assumed that Aristotle was saying that we should seek a lesser kind of certainty in moral philosophy compared, say, to mathematics or physics. In fact, Aristotle only means to say that ethics is less *precise* or *exact* than mathematics. Note that the inexact truths offered by ethics might be proved to the same degree as the exact truths offered by mathematics. For example, Aristotle expresses no

cussed by legal scholars focusing on the reasonable doubt standard in jury trials, the standard is notoriously hard to interpret. It is supposed to signify something greater than a high degree of probability, but it is also sometimes equated with moral certainty and said to be a lower standard than absolute certainty (even though moral certainty is best conceived of as a species of probability). The law can avoid contradiction on this point only by asserting some degree of justification higher than any degree of probability one could assign but lower than absolute certainty. For a survey of the many failed definitions of proof beyond a reasonable doubt, see Mulrine, “Reasonable Doubt: How in the World Is It Defined”.

¹³For more on Gerson and moral certainty, see Schussler, “Jean Gerson, Moral Certainty and the Renaissance of Ancient Scepticism”.

¹⁴*Principles* IV, art. 204, including note, in Descartes, *The Philosophical Works of Descartes*: Vol. 1, p. 290.

¹⁵Aristotle, *Nicomachean Ethics*: 1094b11.

doubt that courage is a virtue; the leeway comes only in using judgment to decide what counts as courage in a given situation. But Aristotle's intentions aside, this passage led others to conceive of moral certainty as involving quasi-demonstrations that might be good enough for ethics, but not good enough for mathematics.

One odd thing about moral certainty is that it typically involves epistemic *uncertainty*. As Descartes says, "the chance for action would frequently pass us by if we waited until we could free ourselves from our doubts."¹⁶ Our reasons for believing something might suffice for ethics or for action without being conclusive. Indeed, as James Franklin has noted, the very function of the idea of "moral certainty" seems to be to serve as an excuse for errors in conduct.¹⁷ During the Enlightenment, accordingly, some philosophers argued that moral certainty is a species of probability, and some of them attempted to quantify it. The French naturalist Georges-Louis Leclerc de Buffon (1707-88) held that a belief is morally certain as long as there is less than one chance in ten thousand that it could turn out to be false.¹⁸ In this case especially, the concept is epistemic, but the bar for accepting a belief is set lower than it is for either of the two conceptions of epistemic certainty mentioned above. A belief can be sufficiently probable to act on without being demonstrated based on self-evident truths and without being indefeasibly justified.

Psychological certainty, in contrast to both epistemic and moral certainty, is not a matter of evidence at all but is rather synonymous with supreme confidence or conviction. Someone who is psychologically certain of a belief at one time may be capable of doubting it or abandoning it in the future if he finds new evidence or thinks of new arguments. He is psychologically certain of the belief only as long as he is so convinced of its truth that he finds himself unable to doubt it. Although this sort of conviction is one of the common meanings of the Latin *certus*, the term "psychological certainty" had not yet been coined in Bacon's time.

Bacon does not in general make clear which kind of certainty, if any of

¹⁶*Principles* I, art. 3 in Descartes, *The Philosophical Works of Descartes*: Vol. 1, p. 193.

¹⁷Franklin, *The Science of Conjecture : Evidence and Probability before Pascal*: p. 70.

¹⁸Loveland, "Buffon, the Certainty of Sunrise, and the Probabilistic Reductio ad Absurdum": p. 466.

these, he has in mind—and of course we should not assume that these categories apply to him or that he distinguishes clearly among them. His claim in the *De augmentis* that “he who makes too great haste to grasp at certainties shall end in doubts, while he who seasonably restrains his judgment shall end in certainties,”¹⁹ as well as his emphasis on making “doubtful things certain,”²⁰ could just as easily refer to psychological certainty as epistemic. To compound the confusion, Bacon on occasion mentions “mathematical certainty,” as for example when he discusses the syllogism,²¹ and this might seem to suggest the medieval distinction between the degrees of certainty appropriate to different fields. In fact it need have nothing to do with that distinction since Bacon may just intend to refer to certainty that happens to result from mathematical reasoning, without thereby meaning to imply that certainties established by non-mathematical reasoning are somehow weaker. Nevertheless, the evidence is hardly as conclusive as one would like it to be.

The best evidence, it turns out, is more indirect. In the next section, I will show, based on Bacon’s evaluation of skepticism, that he does think that epistemic certainty is possible and, furthermore, that the productive success of science depends, in his view, on the belief in the possibility of epistemic certainty regarding the nature of things. I will also provide some initial reasons for thinking that Bacon conceives of epistemic certainty as involving indefeasible justification, though a fuller case for this claim will have to wait until Chapter 3.²²

2.2 Bacon and the Skeptics

It is not obvious how to interpret Bacon’s attitude towards skepticism. If he simply equated skepticism with the denial of the possibility of epistemic certainty, and if he then went on to reject skepticism, then it would be easy to infer that he affirms the possibility of epistemic certainty. In fact there is much more to skepticism than the denial of the possibility of epistemic certainty, and indeed there

¹⁹Vol. 4, p. 429.

²⁰Ibid.: p. 358.

²¹*Distributio operis*, B3^v 8-9.

²²In Chapter 3, see especially the introduction and 3.5.

are skeptics who affirm that we can be certain of some things, such as the fact that we do perceive what we perceive.²³ Furthermore, Bacon's comments on skepticism are not always negative. Perhaps the most apparently positive comment is from a discussion of Academic skepticism in the *Scala intellectus*: "we concur in many things which they have judiciously observed and stated about the varying nature of the senses, the weakness of human judgment, and the propriety of withholding or suspending assent."²⁴ It is important, therefore, to pinpoint exactly what Bacon's understanding of skepticism is and exactly which aspects of it he embraces and which he finds objectionable.

These questions have received limited scholarly attention. In general, scholars have taken one of three views on Bacon's relationship to skepticism: (1) Some, such as Popkin, characterize Bacon as a temporary skeptic, someone who thinks we should suspend judgment for now but stop suspending judgment once demonstrations are available.²⁵ (2) Oliveira and Maia Neto argue that Bacon is a proponent of, or at least tends toward, what Popkin terms "mitigated skepticism," meaning that he tries to offer a model of science that allows for progress in the absence of certainty.²⁶ Urbach, who argues that Bacon aims only to establish knowledge that is good enough to be counted as certain, adopts a similar view.²⁷ (3) Eva sees a relationship between Bacon and mitigated skeptics but stops short of classifying Bacon as one. Instead, he argues that Bacon's idols are the product of the influence of Pyrrhonian skepticism and that these idols, through their influence on the philosophers of the Royal Society, helped give rise to mitigated skepticism. This

²³See Schwitzgebel, "The Unreliability of Naïve Introspection": p. 245. "Current conscious experience is generally the last refuge of the skeptic against uncertainty. Though we might doubt the existence of other minds, that the sun will rise tomorrow, that the earth existed five minutes ago, that there's any 'external world' at all, even whether two and three make five, still we can know, it's said, the basic features of our ongoing stream of experience. Descartes espouses this view in his first two *Meditations*. So does Hume, in the first book of the *Treatise*, and—as I read him—Sextus Empiricus."

²⁴*Scala intellectus*, p. 519. Wormald is mistaken to read this passage as a discussion of Pyrrhonian skepticism, as evidenced by Bacon's reference to the Academic distinction between truth and probability. Wormald, *Francis Bacon: History, Politics and Science, 1561-1626*: p. 364. See below for Bacon's understanding of the distinction between Academic and Pyrrhonian skepticism.

²⁵Popkin, *The History of Scepticism: From Savonarola to Bayle*: pp. 110-11.

²⁶Oliveira and Maia Neto, "The Skeptical Evaluation of Technê and Baconian Science".

²⁷Urbach, *Francis Bacon's Philosophy of Science: An Account and a Reappraisal*: pp. 188-9.

reading admits that Bacon himself probably believed that certainty is possible and that he approved of skepticism only to the extent that it helped expose biases and errors.²⁸

In fact, as will begin to emerge in Chapter 3, Bacon's rejection of skepticism is more thoroughgoing than even Popkin suggests since there is not even a temporary stage during which Bacon can be legitimately likened to a skeptic. Here I need only show that Bacon understood skepticism to involve the denial of the possibility of epistemic certainty about the real nature of things and that he rejected this denial and regarded it as a threat to scientific progress.

Bacon reacted to both Renaissance and ancient skeptics. His reaction to Agrippa (1486-1535) is evident in the jab at the latter's *De incertitudine et vanitate scientiarum atque artium declamatio invectiva* (*Declamation Attacking the Uncertainty and Vanity of the Sciences and the Arts*) within the title of his own *De dignitate et augmentis scientiarum* (*Of the Dignity and the Advancement of the Sciences*).²⁹ Indeed, the attack is not confined to the title. In the first book of the *De augmentis*, Bacon responds in detail to a number of criticisms that had been directed towards the sciences, including some that can be found in Agrippa's text (among other places), such as the claim that the choice by Adam to pursue knowledge caused the fall of man. It is not clear, despite this attack, whether Bacon classed Agrippa with the skeptics (Popkin, regarding Agrippa as too anti-intellectual, seems to resist such a classification), and even if Bacon did regard Agrippa as a skeptic, he would have recognized that his skepticism was of a lower caliber. In his essay "Of Truth," Bacon says that there are no longer any skeptics, but only "certain discoursing wits which are of the same veins, though there be not so much blood in them as was in those of the ancients."³⁰ A lack of blood could refer to a lack of philosophical sophistication or to an unwillingness to commit

²⁸Eva, "On the affinities between Bacon's philosophy and skepticism". Silvia Manzo adopts a hybrid of the first two views here. As a theoretical philosopher, according to Manzo, Bacon aims to refute the skeptic, but as a practicing scientist he settles for a probabilistic science that falls short of that standard.

²⁹We know that Bacon read Agrippa's *De vanitate*, so the choice of the title can hardly be a coincidence. For evidence that Bacon read Agrippa's *De vanitate*, see Oliveira and Maia Neto, "The Skeptical Evaluation of Technê and Baconian Science": p. 253.

³⁰Bacon, *The Essays*: p. 61.

fully to the philosophy (e.g., by leaving room for revealed knowledge). In either case, it seems that Bacon regarded the ancient skeptics as more important and more worthy of attention; thus, at the risk of neglecting Bacon's more immediate context in the history of philosophy, I too will direct my attention to them.

Bacon distinguishes, as we do, between two main varieties of ancient skepticism, Academic and Pyrrhonian skepticism. He does not discuss Pyrrhonian skepticism often. All he says in the *Novum organum* is that it "confound[s] inquiry" altogether and is thus less honest than Academic skepticism.³¹ This is a reference to the fact that Pyrrhonian skeptics, at least in Bacon's understanding, advocate the complete suspension of judgment about the world. They do not even have a category of probable truths to which it is appropriate to assent in the face of uncertainty. His mention in the same passage of "*Pyrrho* and the *Ephectics*" suggests that he may have derived this view from Diogenes Laertius' *Life of Pyrrho* (see the passage below), although Montaigne's *Apology for Raymond Sebond*, which also uses the term "Ephectic," is an additional possibility.³² If the former, then this passage probably captures Bacon's understanding of Pyrrhonian skepticism:

All these men were called Pyrrhonians from their master; and also doubters, and sceptics, and ephectics, or suspenders of their judgment, and investigators, from their principles. And their philosophy was called investigatory, from their investigating or seeking the truth on all sides; and sceptical from their being always doubting and never finding; and ephectic, from the disposition which they encouraged after investigation, I mean the suspending of their judgment.³³

Notice that even after investigation, they encourage suspension of judgment.

³¹*N.O.* I. 67.

³²The extent of Bacon's familiarity with Montaigne is a subject of debate. Vickers asserts that Bacon "certainly read Montaigne in French" (xxxiv). Bacon, *The Major Works*. While this much is true, it is not clear just how much of him he read. There is some evidence that Bacon may have read the "Apology for Raymond Sebond" in particular since, as it turns out, Bacon alludes in the *Descriptio intellectualis globis* to the same anecdote about Democritus and figs that Montaigne recounts in the "Apology," even though the original source of the anecdote (Plutarch's *Moralia*), and most translations, refers to cucumbers, not figs. This would be definitive evidence that Bacon read Montaigne's "Apology" were it not for the fact that Bacon read some of Plutarch in the same French edition from which Montaigne got his mistranslation (Vickers, p. 655). For a concise summary of other aspects of this debate, see Oliveira and Maia Neto, "The Skeptical Evaluation of Technê and Baconian Science": p. 256, n. 25.

³³"Life of Pyrrho" in Diogenes Laertius, *The lives and opinions of eminent philosophers*: VIII.

Academic Skepticism receives a fuller treatment from Bacon. He first addresses it in the *Scala intellectus*:

For no matter how they want to be seen, through their distinction between the true [*veri*] and the credible [*probabilis*], to destroy the certainty of science [*scientiae certitudinem*] but to retain its usefulness, and, as far as the practical part [*activam partem*] goes, to leave our prized possessions uninjured, nevertheless, having lifted from the souls of men the hope of inquiring into the truth [*veritatis*], and obtaining an indiscriminate license, they have turned the work [*negotium*] of discovery into a sort of exercise of wit and disputation.³⁴

He repeats the same criticism in the *Novum organum*. “Once the human soul has lost hope of discovering the truth, everything becomes more supine; and the result is that [those of the New Academy] turn men to agreeable debate and argument, and dodging hard facts, rather than keep them in the way of rigorous inquiry.”³⁵ In the *De augmentis* he likewise characterizes Academic skeptics as “[denying] any certainty of knowledge or comprehension; affirming that the knowledge of man extended only to appearances and probabilities.”³⁶

In all of these passages Bacon recognizes that Academic skeptics attempted to mitigate their skepticism. Unlike the Pyrrhonians, they do not call for the suspension of judgment regarding that which resembles the truth or which is persuasive enough to be worthy of approbation. Notice that the standard which Bacon attributes to the Academics sounds very much like the standard of moral certainty as it was understood at the time—as certainty sufficient for action, although Bacon focuses on action related to scientific inquiry rather than action in daily life. As Bacon puts it, the Academics seek a level of credibility that is high enough to allow the *operative* part of science, such as the manufacturing of technology, to move forward without any detrimental impact.

So Bacon’s dissatisfaction with the Academics reflects an ambition for a higher degree of justification than moral certainty. The *De augmentis* passage implies the view that we must pursue certainty not just regarding what appears to

³⁴Bacon, *The Works of Francis Bacon, Lord Chancellor of England*: Vol. 2, pp. 687-8, my translation.

³⁵*N.O.* I. 67.

³⁶Vol. 4, p. 412.

be the case but regarding what actually is the case. So Bacon seeks some kind of certainty about the real nature of things.³⁷ Furthermore, the criticisms offered by Bacon here make good sense if one reads them as criticisms of the idea that moral certainty can serve as the highest epistemic standard. Consider his charge that the Academics offer an indiscriminate license for belief. The worry seems to be that even though some credible beliefs are more justified than others—and importantly, some will be undermined by subsequent reasons for doubt, while others might not be but will be firm and stable—the Academic offers no reason to seek higher degrees of justification once moral certainty is reached. Bacon disagrees and indicates that a special epistemic category is needed at the top, as it were, a category which can continue to motivate the hard work of science until the truth (which, as the truth, cannot be undermined by subsequent reasons for doubt), and not just the truth-like, is obtained.

So Bacon must believe that we should seek epistemic certainty about the nature of things, and he must conceive of epistemic certainty as at least involving indefeasible justification. It is not likely that he conceives of epistemic certainty as involving anything more demanding than indefeasible justification, such as *scientia*, since that proposal hinges on a deductivist approach to science. But the standard is also not likely to be any weaker, or else it becomes difficult to distinguish Bacon from the Academic skeptic. For additional evidence that Bacon is best understood as conceiving of epistemic certainty as indefeasible justification, and for a fuller treatment of the nature of this indefeasible justification, see 3.5.

³⁷One might argue that Bacon would defend the possibility of certainty even if he were not himself sincerely convinced that certainty is possible. The promise of certainty would on this view be a sort of noble lie that he might regard as necessary to stimulate scientific progress. This is not entirely outside the realm of possibility. For now, it is enough that I establish that Bacon's official position is that certainty about the nature of things is possible; later chapters, taken collectively, will show that Bacon has enough to say about the certainty of science that we should not regard his promise of certainty as a noble lie. The fact that my main concern here is just with establishing Bacon's official position also helps mitigate another possible objection. It is unclear why the potential for higher degrees of moral certainty would be much less motivating than the potential for epistemic certainty. Therefore, I do not think that this consideration by itself offers much in the way of a defense of Bacon's attitude towards certainty, although it does indicate what his position is. I will touch on this argument again in 3.4.

2.3 The Certainty of Part Six

The preceding section serves to undermine the arguments of Urbach and Gaukroger. Urbach has argued that Bacon is not interested in epistemic certainty, but only in gathering enough proofs to render a thesis “so convincing that it is considered practically certain.”³⁸ Stephen Gaukroger has said that Bacon “is not concerned so much with the degree of certainty of results in natural philosophy (he has no time for skepticism in this regard, for example), but in making natural philosophy informative and productive.”³⁹ As I have argued, the belief in epistemic certainty is a crucial ingredient in Bacon’s attempt to make natural philosophy productive. If we settle for moral certainty, in Bacon’s view, then people will not pursue science with the proper earnestness and determination.

A different view of Bacon’s attitude toward certainty—one which I take to be relatively common—agrees with this conclusion.⁴⁰ This reading of Bacon states that (1) Bacon’s goal is epistemic certainty regarding causes, (2) only Part Six of the *Instauratio* exhibits epistemic certainty, and (3) Bacon is therefore a temporary skeptic in the sense that his attitude towards knowledge claims resembles that of the Academic skeptic, until such time as the work of science is entirely finished. In this section, I will argue that this focus on Part Six is misplaced. It is not just the case that we shouldn’t *end up* as skeptics after finishing our scientific inquiries. We should not start as skeptics either.

2.3.1 Arguments for Restricting Certainty to Part Six

There are, to be sure, arguments for this reading, but commentators have not been particularly forthcoming with them. Lisa Jardine offers just this passage from the *De augmentis*:

³⁸Urbach, *Francis Bacon’s Philosophy of Science: An Account and a Reappraisal*: pp. 188-9.

³⁹Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy*: p. 159.

⁴⁰Among the authors who support this view, in whole or in part, are Lisa Jardine, Henry Van Leeuwen, and Barbara Shapiro, all discussed below, and Richard Popkin (see n. 24 above). Jardine, for example, says that “the contents of the fifth part of Bacon’s *Instauratio magna* have the status of the Academic skeptic’s always tentative and provisional statements [...] they enable the investigator to act in the absence of a currently inaccessible certainty.” Jardine, “*Experientia Literata* or *Novum Organum*? The Dilemma of Bacon’s Scientific Method”: p. 57.

Physic handles those things which are most deeply immersed in matter and changeable, Metaphysic those which are most abstracted and constant. Again, Physic posits in nature only existence, motion, and natural necessity; Metaphysic adds mind and idea [...]. We have referred the inquiry into causes to the theoretical branch of natural philosophy. We have divided this into Physic and Metaphysic. It follows that the real difference between them derives from the nature of the causes they investigate [...]. *Physic* is the inquiry into *efficient* and *material* cause; *Metaphysic* into *formal* and *final*.⁴¹

On the basis of this passage, she comments:

Bacon here claims that the abstracted natures of metaphysics can be derived from the regularities of physics—that from the moral certainty (as Descartes called it: certainty on a par with *scientia* in the other field of investigation deeply immersed in matter) of physics we can get directly to the absolute necessity of metaphysics. And it is that absolute necessity which he sets himself unequivocally (albeit only notionally) as the goal of his scientific method.⁴²

Jardine’s reading of the *De augmentis* passage notwithstanding, Bacon says nothing there to the effect that metaphysics is derived from physics and nothing about certainty (whether moral or epistemic). The claim that physics has to do with that which is “deeply immersed in matter” does not imply that it has the status of moral certainty.⁴³ Bacon just does not claim in this passage what Jardine says he claims.

A more plausible argument for the standard reading, one which may explain Jardine’s otherwise mysterious reading of the *De augmentis* passage, is based on Bacon’s discussion of the certainty of forms and rules of operation in the *Novum organum*. This argument relies on Bacon’s apparent claim in II. 4 that in seeking certainty, what he seeks are formal causes whose presence guarantees the presence of the natures that are their effects.⁴⁴

⁴¹Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 1, p. 550, as quoted in Jardine, “*Experientia Literata* or *Novum Organum*? The Dilemma of Bacon’s Scientific Method”: p. 58. Jardine’s translation and elisions.

⁴²Ibid.

⁴³In fact, as will become clear, Bacon’s talk of immersion in matter and of the inconstant nature of the causes of physics refers to the fact that physics fails to meet the requirement of liberty, not certainty.

⁴⁴I will discuss *N.O.* II. 4 in more depth in the next section. Some of the terminology here will have to remain unclear for now.

Thus in the matter of a true and perfect precept for operating, this would be the prescription: *that it be certain, unrestricted, and arranged and lined up for action*. And this very prescription goes for the discovery of a true form. For the form of any nature is such that if it be in place the given nature invariably follows. Thus it is constantly present when that nature is present, and universally asserts it, and inheres in the whole of it. The same form is such that if it departs, the given nature infallibly disappears. Thus it is always absent when that nature is absent, and always withholds it, and inheres in it not at all. Lastly, a true form is such that it draws up the given nature from some source of being which inheres in many other things, and is (as they have it) better known to nature than the form itself.⁴⁵

Jardine, based on Bacon's claim in the *De augmentis* that physics studies that which is fluctuating and changeable, and also based on his claim here that the prescription for certainty is for natures that follow from other natures invariably or without exception, concludes that physics lacks this certainty, while metaphysics (which includes the study of forms) has it. In physics, the cause may be present and the effect fail to follow. Not so in metaphysics. Thus, physics is uncertain and metaphysics certain.

Van Leeuwen seems to agree with Jardine. He mentions the fact that Baconian formal causes provide sufficient conditions for the presence of natures. "Whenever the laws apply one can deduce the presence of the nature."⁴⁶ He immediately ties this feature of forms to epistemic certainty. "Anything less than such knowledge deduced from forms does not qualify as knowledge of nature. Thus for Bacon scientific knowledge is demonstrative and is absolutely certain."⁴⁷ Finding sufficient conditions is a means to certainty, and there is no certainty prior to the discovery of those sufficient conditions.

Barbara Shapiro offers a modified version of this argument by pointing to a passage in the *De augmentis*: "For knowledges are as pyramids, whereof history and experience are the basis. And so of Natural Philosophy the basis is Natural History; the stage next the basis is Physic; the stage next the vertical

⁴⁵*N.O.* II. 4, italics in the original Latin and in the English translation.

⁴⁶Van Leeuwen, *The Problem of Certainty in English Thought 1630-1690*: p. 5.

⁴⁷*Ibid.*

point is Metaphysic.”⁴⁸ And at the top, Bacon continues, is something called “the summary law of nature.” Shapiro comments that natural history leads to the “certitude of physics and eventually to the forms,” and she makes clear that she means to refer to the “certainty of mathematical demonstration” and thus to epistemic certainty.⁴⁹ The passage Shapiro points to says nothing about certainty, however, so it is unclear why she makes this claim. As was the case with regard to Jardine, Shapiro’s otherwise mysterious claim makes more sense if we assume that she is defining certainty in terms of sufficient conditions. When the efficient causes of physics are present, their effects are guaranteed to follow. (Here Shapiro disagrees with Jardine, who restricts such certainty to metaphysics.) It is difficult to be sure that this is Shapiro’s reasoning, but why else would certainty first become possible at the middle of the pyramid? The middle of the pyramid is distinguished only by the fact that sufficient conditions first enter into the picture here.

In the rest of this chapter, I will argue that the certainty associated with forms is not the epistemic certainty implied by Bacon’s rejection of Academic skepticism. To present that argument, I first have to introduce Bacon’s framework and some of his terminology, in which his discussion of forms is couched. This discussion will have the added benefit of laying the groundwork for the discussion of Baconian natural history and induction later on in Chapters 4 and 5.

2.3.2 Goals and Terminology of Baconian Science

The purpose of Bacon’s induction is to arrive at notions and axioms that accurately reflect the world.⁵⁰ A notion is an abstract idea, such as “substance,” “heavy,” “light,” “being,” “hot,” “cold,” “man,” or “dog.”⁵¹ An axiom, as Bacon uses the term, refers to any proposition of universal scope (and therefore it is a proposition from which conclusions and, at least if the axioms are derived

⁴⁸Vol. 4, p. 362.

⁴⁹Shapiro, *Probability and Certainty in Seventeenth-Century England*: p. 24.

⁵⁰*N.O.* I. 105.

⁵¹*N.O.* I. 15-16. Note that Bacon is critical of Aristotelian definitions of some of these notions, but they are notions nonetheless. For a discussion of the use of the term *notio* in late sixteenth century Aristotelian scholarship, see McCaskey, “Regula Socratis: The Rediscovery of Ancient Induction in Early Modern England”: pp. 237-9.

from experience, works can be derived).⁵² They can be of high generality (Bacon sometimes refers to these as principles), medium generality (these are the middle axioms on which Bacon lays much emphasis), or low generality, although “the lowest axioms barely differ from naked experience.”⁵³ “All dogs bark,” for example, would be a fairly low-level axiom. Axioms and notions are connected in two ways. First, axioms, like all propositions, acquire their meaning from the notions that enter into them: “the syllogism is made up of propositions, propositions of words, and words are the tokens and signs of notions.” And second, the definition of a notion is a kind of axiom. It is a universal proposition about all of the instances of a kind.

All notions are notions of natures. A notion is a mental object; a nature is a property in the world to which a notion corresponds. To the notion of “dog,” there is a correspondent nature in the world that we call “dogness.”⁵⁴ Natures can be either simple or compound. Simple natures are qualities, such as “hot,” “cold,” or “heavy.” Compound natures are sets of qualities that jointly define some kind of substance.⁵⁵ See also *N.O.* II. 7, 17. For example, goldness or the property of being gold is a compound nature; it is a complex of such simple natures as “yellowness,” “malleability,” and “density.” What makes gold gold, in other words, is that these and other simple natures “come together and become intertwined.”⁵⁶ Wherever those natures come together, gold exists.

When axioms have been perfected, they are added to the sixth part of the

⁵²The *Oxford English Dictionary* attests to Bacon’s contemporaries using the term roughly how we would use words such as “principle,” “law,” and “rule.” See “Axiom” in *Oxford English dictionary online*.

⁵³*N.O.* I. 104.

⁵⁴Strictly speaking, according to Bacon, only particulars exist, including bodies, rational souls, and God. See *N.O.* II. 2, which asserts that only *bodies* exist in nature, but compare to *De augmentis* IV. 3, where Bacon implies that the rational soul is non-material, a view which is strictly speaking incompatible with *N.O.* II. 2—unless Bacon holds that the rational soul is not a part of nature. He may very well hold this view since here in the *De augmentis* he calls the rational soul “divine” (Vol. 4, p. 396) and says that “the substance of the soul in its creation was not extracted or produced out of the mass of heaven and earth, but was immediately inspired [breathed into us] from God” (Vol 4, p. 398). God is not for Bacon a part of nature. In any case, as I said, only particulars exist, in Bacon’s view. Although there are no mind-independent universals, the particular bodies fall into categories or classes. A nature is what makes something part of one class rather than another.

⁵⁵*De augmentis*, Vol. 4, pp. 360-1.

⁵⁶*N.O.* II. 7.

Instauratio. Not just any axiom can go into Part Six, though. For two reasons, Bacon limits the sixth part to those axioms which concern causes: first, because knowledge of universals is not secure unless it is grounded in knowledge of causes;⁵⁷ and second, because our goal is to manipulate nature for the good of mankind, and such manipulation requires that we know how to cause the effects that we want.⁵⁸ Bacon adopts the Aristotelian distinction between formal, efficient, material, and final causes. This division of causes then forms the basis of his partition of the sciences. Metaphysics, as the study of what things essentially are, is the study of formal causes, and physics, as the study of the constitution of bodies and their changes, is the study of material and efficient causes. Let us consider the place of each kind of cause in turn.⁵⁹

The form or formal cause of a nature is the answer to the question, “What is it?” In Bacon’s inquiry into heat in Book Two of the *Novum organum*, “heat” is the nature under investigation. The goal is find another nature (“motion”) which, when delimited by other natures (“expansive,” for example), explains what “heat” is. That other nature, thus delimited, is the formal cause. And when that formal cause is predicated of all instances of heat in the form of a proposition, the result is an axiom that states the definition of the nature under investigation. Forms and definitions are thus closely related; a definition is a statement of the formal cause.

Knowledge of forms is potentially very powerful since it makes it possible in principle to generate in any given body any number of properties, thereby opening the door to the transformation of any substance into any other substance.⁶⁰ That said, Bacon recognizes that it is not obvious how to apply our knowledge of forms to create effects in the world. Although generating just one nature in a body is easy (who doesn’t know that we can make something hot by means of fire or

⁵⁷ “For it is not reasonable to allege, that the true knowledge of anything is to be attained before the mind has a correct conception of its causes.” Bacon, *The Works of Francis Bacon, Lord Chancellor of England: Scala intellectus*, p. 519. Cf. *N.O.* II. 2.

⁵⁸ *N.O.* II. 1, 3.

⁵⁹ I will omit a discussion of final causes. Although Bacon allows them a role in the science of human beings, he rejects them from natural philosophy and never says very much about them.

⁶⁰ “Thus an axiom of this sort brings the matter down to the forms of simple natures. For he who knows the forms and the means of superinducing yellow, weight, ductility, fixity, fluidity, dissolution, and the rest in their proper degrees and amounts, will see to it that these can be conjoined in a particular body to bring about its transformation into gold.” *N.O.* II. 5.

friction?), generating many natures in a single body in order to transform it into another substance is much harder. After all, generating the natures one by one will not generally work. In the endeavor to make gold out of lead, we would not want to start by painting the lead yellow. So even if we knew all of the properties of gold, we would not have an easy time taking a piece of lead and transforming it into gold.

This is why we need to know about other causes besides formal causes, especially efficient and material causes. Bacon calls the efficient cause the “latent process” (*latens processus*, latent here meaning concealed) and objects to the Aristotelians for focusing only on visible and discontinuous stages in the generation of things, when they say, for example, that the efficient cause of a plant is a seed. Bacon thinks we must investigate what goes on in bodies, perceptibly and imperceptibly, from moment to moment. Proceeding by way of efficient causes thus understood “seems more accessible, closer to hand, and to give more grounds of hope” than proceeding based on formal causes alone.⁶¹ If we are trying to make gold, we might want to observe how gold is created naturally beneath the earth. If we can mimic the earth in our laboratory, we will have *one* way of producing gold. Ideally, though, we would also know the form of gold. Otherwise, we will have just the one way of producing gold and might not be able to produce it by means of the materials we have available.

The “latent schematism” (*latens schematismos*), or material cause, refers to the constitution and organization of bodies. (A more illuminating rendering of the Latin would be “concealed configuration.”) Like the knowledge of the latent process, the knowledge of the latent schematism can be used even in the absence of the knowledge of the form, but it suffers from the same shortcoming. Because it pertains to “the common and ordinary course of nature, and not to her fundamental and everlasting laws,”⁶² it is useless unless we already have the required materials and know how they can be mixed or joined together. After all, we all know the material cause of water; it is composed of hydrogen and oxygen. Yet based only on this knowledge we do not have the ability to take hydrogen and oxygen and create

⁶¹Ibid.

⁶²*N.O.* II. 9.

water out of it. Knowing only the latent schematism leaves us with a narrow range of means of producing effects. The chief value in knowing the latent schematism, then, is as a supplement to our knowledge of the formal cause. “Yet no one can endow a given body with a new nature or successfully and appropriately convert it into a new body unless he has acquired a good understanding of the body to be altered or transformed.”⁶³ We need to manipulate bodies to superinduce forms onto them, and that would be an impossible task without knowing something about the constitution of the bodies we are working with.

We are best off when we know all three of these kinds of causes, although even then there are no guarantees. Bacon expresses hope that it will one day be possible to manipulate bodies at a submicroscopic scale (moving around the smallest particles, whatever they happen to be).⁶⁴ Bacon calls this a kind of magic, whereas we call it nanotechnology, but in any case it requires at least a knowledge of the formal cause and the latent schematism of the thing being created.

Having covered these preliminaries, we can now return to the certainty that Bacon mentions in connection with the topic of forms. This is the topic of *N.O.* II. 4, which I mentioned above as a possible motivation for Jardine’s interpretation; we should now consider the passage, and its context, more carefully (and therefore I must quote it at length). Bacon mentions such “certainty” in the context of a wider discussion about the need for a particular kind of precept or rule of operation:

Thus we should consider, for the purpose of generating and superinducing any nature on a given body, what precept, direction, or procedure someone would most wish for; and put that in the most simple and least recondite terms.

For example, if someone wanted to superinduce on silver the yellowish colour of gold, or (in compliance with the laws of matter) an increase in weight, or transparency on some stone lacking it, or tenacity on glass, or vegetation on something lacking it, we must (I say) consider what precept or procedure he would most like to have. Now in the first place, [A] someone will doubtless want to be shown something of a kind that will not let him down in the operation or deceive him in the experiment. Secondly, [B] he will want to have something laid down for him which

⁶³*N.O.* II. 7.

⁶⁴*N.O.* II. 51.

will not restrict or tie him to certain means and certain specific modes of operating. For perhaps he may lack or not not be able conveniently to get hold of or lay hands on the specific means in question. But if there be other means or modes (besides the one recommended) for producing a particular nature, there will perhaps be some among them which lie within the operator's power but from which he is shut out by the narrow scope of the precept, so that he does not derive any advantage. Thirdly, [C] he will want to be shown something which is not as difficult as that very operation he is investigating, but something which is handier for practice.

Thus in the manner of a true and perfect precept for operating, this would be the prescription: *that it be* [A] *certain*, [B] *unrestricted*, and [C] *arranged or lined up for action*. And this very prescription goes for the discovery of the true form. For the form of any nature is such that [A1] if it be in place the given nature invariably follows. Thus [A2] it is constantly present when that nature is present, and [A3] universally asserts it, and [A4] inheres in the whole of it. The same form is such that [B1] if it departs, the given nature infallibly disappears. Thus [B2] it is always absent when that nature is absent, and [B3] always withholds it, and [B4] inheres in it not at all. Lastly, [C1] a true form is such that it draws up the given nature from some source of being which inheres in many other things, and is (as they have it) [C2] better known to nature than the form itself. Thus for a true and perfect axiom for knowing, the prescription and precept is this: *that there be discovered another nature which is convertible with the given nature, but which is nevertheless a limitation of one better known to nature like a true genus*. And these two prescriptions, the active and the contemplative, are the same thing; for what is most useful in operating, is most true in knowing.⁶⁵

Bacon begins by referring back to what he has stated is the goal of human power: we want to find rules for how to manipulate bodies so as to change their natures. Now Bacon observes that not just any rules will do. He specifies three conditions on these rules. First, we want rules “of a kind that will not let [us] down in the operation or deceive [us] in the experiment.” In other words, we want the rules to

⁶⁵*N.O.* II. 4. The text in brackets has been added by me. I have added an A where I believe Bacon is addressing factors relevant to certainty, a B where I believe he is addressing factors relevant to the lack of restraint, and a C where I believe he is addressing factors relevant to a rule's being fitted for practice. Where there are a number of formulations of each of these, I have also numbered them, i.e., A1, A2, A3, and A4 are, I take it, four different formulations of what it means for a rule to be certain.

work universally and not to fail us in particular cases. Second, we want rules that “will not restrict or tie [us] down to certain means and certain specific modes of operating.” That is to say, we want rules that will give us the freedom to work with a broad range of materials. For example, if our rule for generating fire requires that we already have a match, then our rule is rather weak. And third, we want rules that are practicable, in that they call for bodies to be manipulated in a way that is familiar to us, even though some relatively unfamiliar change occurs as a result (e.g., manipulating density, which is a relatively familiar quality, might create a change in heat, which is a less familiar one). Bacon then introduces the term “certainty” to describe the first condition on these rules and the term “free (*liberum*)” to describe the second. Bacon’s term for the third condition—which is that the rules be “arranged or lined up for action”—is a little unwieldy, so I will just call it a condition for practicality.

Although these conditions are first introduced as features of the perfect rules that we would wish for, Bacon quickly observes that statements of formal causes have all of these features. “And this very prescription goes for the discovery of the true form.”⁶⁶ Before going any further, it is important that we clarify the relationship between forms and rules. It might help here to look at Bacon’s statement of the form of heat and the rule of operation that he goes on to derive from it. The form is stated thus:

*Heat is an expansive motion, but restrained and struggling by way of the lesser parts. But the expansion is modified, so that in expanding all round, it nevertheless tends to rise upwards. The struggle by way of the parts is also modified, so that it is no altogether sluggish but driven on and with some vigour to it.*⁶⁷

Here, the form of heat is predicated of all instances of heat. Thus, this is an axiom. Bacon next translates this axiom into a rule for the operative part of science:

If in any natural body you are able to spark off a motion of self-dilation or expansion, and to repress the motion and turn it back on itself in such a way that the dilation does not go forward smoothly but is now

⁶⁶Ibid.

⁶⁷N.O. II. 20.

*given its head and now forced to retreat, then without doubt you will generate heat.*⁶⁸

Here we have a rule for generating heat; if we bring about the formal cause of heat, then heat will always follow. In other words, the statement of a formal cause always implies a rule of operation. Something cannot be a true statement of the formal cause unless it is possible to derive perfect rules of operation from it. It turns out, then, that true statements of a formal cause have three features that correspond to the three requirements of perfect rules.

If I may continue to simplify II. 4 for a moment—I will comment below on the alternate formulations it contains for each of those three requirements—it accordingly discusses three distinct features of forms. The earlier requirement for certainty, defined as the requirement that a rule not let us down in practice, corresponds to the point that a statement of a form must include sufficient conditions for the presence of a nature. If the form is in place, so is the nature. If we take the predicate *F* to mean “has the form,” and the predicate *N* to mean “is of the given nature,” and if *x* ranges over all objects in the universe, then a statement of a form must be such that $\forall(x)(Fx \rightarrow Nx)$.

The earlier requirement for liberty, or for rules that will not restrict us to specific means of operating, corresponds to the point that a statement of a form must include necessary conditions for the presence of a nature. When the form departs, the nature departs. The connection with the earlier idea of liberty is clearest when one considers the case of sufficient conditions that are not also necessary. The knowledge of sufficient but unnecessary conditions provides one with *a* way to produce a nature, but there are also other ways that involve completely different materials or methods. By isolating just the necessary conditions, one can find a way to produce the nature that will apply no matter the context. If we take the predicate *F* to mean “has the form,” and the predicate *N* to mean “is of the given nature,” and if *x* ranges over all objects in the universe, then a statement of the form must be such that $\forall(x)(\sim Fx \rightarrow \sim Nx)$ or, equivalently, the contrapositive $\forall(x)(Nx \rightarrow Fx)$.

⁶⁸Ibid.

Finally, the statement of the form allows us to infer rules that meet the practicality condition because it “draws up the given nature from some source of being which inheres in many other things.”⁶⁹ Heat, for example, is a kind of motion. “Motion,” as the genus of heat, is a source of being which inheres not only in hot things, but in many other things as well. It is only a specific kind of motion that brings with it heat. To see why a genus is related to practicality as defined earlier, we can consider what a form would be like if our knowledge of it allowed only certainty and liberty, that is, if our statement of the form involved an unstructured, non-hierarchical list of necessary and sufficient conditions. Heat would then be expansive, upward, checked, and a kind of motion. With such an unstructured list, we can try to bring the nature into the world by taking the properties one by one—try to make something expand, move the thing upward, etc.—but this is quite a stab in the dark. If we know from the beginning that we are trying to get something to move in a very specific way, and if we know about motion not just from instances of heat but from a wider class of instances as well, then we are in a much better position.

In fact, the problem with an unstructured list goes still deeper. If one does not first have the genus, it is difficult to imagine how he would even begin to investigate the differentia. One is not likely to discover that heat is expansive until after first discovering that it is a kind of motion. In other words, one would never be able to arrive at an unstructured list of the sort suggested by my example. Still, my example seems to illustrate what Bacon has in mind by the requirement that I am calling “practicality.’

A closer reading of the passage complicates this picture somewhat. A1 appears to assert that forms are sufficient conditions for corresponding natures, but it is not clear how A2, A3, and A4 are supposed to follow from this point. In fact, A2 appears to have it the other way around, asserting instead that forms are necessary conditions of natures. And of course it is invalid to infer from something’s being a sufficient condition for N that it is also a necessary condition for N. The meaning of A3 and A4, meanwhile, is hard to decipher. What does it mean to say

⁶⁹Ibid.

that a true form universally asserts a nature or that it inheres in the whole of a nature?

I think it is best to attribute the formulation in A2 to sloppiness. Bacon may have intended to say that the form and the corresponding nature are often seen together because the form is guaranteed to produce the nature. According to a possible reading of A3, to assert a nature is to predicate it of a given body. So a form might universally assert a nature because, in all instances, that form implies that the nature should be predicated of the body having the form. On this reading, A3 is another formulation of the claim that forms are sufficient conditions for corresponding natures. In A4, Bacon has shifted to terminology associated with categorical logic. There is a category of things with a given form, and there is a category of things having the corresponding nature. The first category inheres in the whole of the second, meaning that every instance of the first category is an instance of the second category. So again, this is just another way of saying that forms are sufficient conditions for corresponding natures. (Remember that the categories actually end up being coextensive, but Bacon has only addressed “certainty” so far.)

The alternate formulations of liberty have to be read similarly. B2, which seems to assert that forms are sufficient conditions of corresponding natures, is sloppy. B3, which says that when a form departs, it withholds a corresponding nature, means that that nature is not predicated of any instances where the form is lacking. And B4, like A4, shifts to the terminology of categorical logic. The category of things with the form does not at all fall within the category of things lacking the corresponding nature. As we should expect, then, this is just another way of saying that the form is a necessary condition for a corresponding nature.

An important passage in the *Valerius terminus* confirms my understanding of the relationship between forms and rules of operation. The context is a discussion of the need for a method by which we can discover new inventions and works, which, as we’ve seen, is the goal of Baconian science. Bacon employs a number of metaphors to make his point. Among them is a comparison to archery:

If therefore the true end of knowledge not propounded hath bred large error, the best and perfect condition of the same end not perceived will

cause some declination [turning aside]. For when the butt [target] is set up men need not rove [shoot arrows at random targets; by extension, to conjecture], but except the white [i.e., the white portion of the target, the bulls-eye] be placed men cannot level [aim].⁷⁰

Bacon is saying first that the pursuit of the wrong end—knowledge for its own sake, for instance—has caused wild errors, as if we were shooting at random; but second, even though some others do aim for practical ends, they fail to grasp the nature of their target and thus they still miss the mark. This latter group has the target set up, but not the bulls-eye. Here, as in the *Novum organum*, Bacon is emphasizing the need for a search for a more perfect kind of rule of operation.

What mark should we be aiming for? “The fulness of direction [i.e., perfection of aim] to work and produce any effect consisteth in two conditions, certainty and liberty. Certainty is when the direction is not only true for the most part, but infallible. Liberty is when the direction is not restrained to some definite means, but comprehendeth all the means and ways possible.”⁷¹ It follows from this, Bacon continues, that a certain direction “must refer you and point you to somewhat which, if it be present, the effect you seek will of necessity follow, else may you perform and not obtain.”

Bacon continues by equating his requirement for certainty with what he calls Aristotle’s “rule of truth.” This is Ramus’ term for a principle which originates from the *Posterior Analytics* I. 4 discussion of universal predication, or predication *kata pantos* (in Greek) or *de omni* (in Latin). Aristotle explains this term as follows:

I apply the term “predicated of all” [*kata pantos*] to whatever is not predicated of one instance but not of another, or predicated at one time but not at another. E.g., if animal is predicated of all man, if it is true to call X a man, it is also true to call him an animal; and if the former statement is true now, so is the latter.⁷²

If one were to state that heat is a kind of rarity, this would violate the rule of *de omni* because the property of being hot is not predicated of all rare things.

⁷⁰Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 3, p. 235.

⁷¹Ibid.

⁷²Aristotle, *Posterior Analytics*: 73a29-32.

Air can be rare but cold, for instance. The nature being investigated must be universally predicated of the form, i.e., the statement of the form must specify sufficient conditions for the presence of the nature. That, he says, is what allows for certainty.

Next Bacon equates liberty with what he calls Aristotle's "rule of prudence."⁷³ This is Ramus' term for predication in virtue of what something essentially is. Although it is true, for example, that all isosceles triangles have an angle sum equal to two right angles (and thus this property is universally predicated of all isosceles triangles), this property does not hold of isosceles triangles in virtue of their being isosceles, but rather in virtue of their being triangles. Not only must the nature under investigation be universally predicated of the form, then, but it must also be predicated of the form in virtue of what it essentially is.

Bacon gives this example: "Let the effect to be produced be Whiteness; let the first direction be that if air and water be intermingled or broken in small portions together, whiteness will ensue, as in snow, in the breaking of the waves of the sea and rivers, and the like. This direction is certain, but very particular and restrained, being tied but to air and water."⁷⁴ The nature under investigation, whiteness, is universally predicated of the intermingling of air and water, but it is not predicated of this in virtue of what whiteness essentially is. The result is that the axiom provides us with one guaranteed way of producing whiteness, but it is a limited one. It binds us to particular materials. This is the sense in which we are not yet at liberty. By finding just the necessary conditions, more options open up to us, and we should in the end be able to produce whiteness using any bodies whatsoever.

2.3.3 The Certainty of Rules as Non-Epistemic

An important implication of this discussion is that there are axioms and rules of operation other than those stemming from our knowledge of forms which possess certainty, in the sense of certainty currently being employed. Indeed, we

⁷³Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 3, p. 236.

⁷⁴Ibid.

have just seen an example of such an axiom in the proposition that all instances of intermingled air and water are white. This axiom is certain despite the fact that it is not associated with our knowledge of a form. It states a sufficient condition, not necessary *and* sufficient conditions. To put it another way, it is such that it would not let us down or deceive us in practice. It always works, although it is not yet a perfect rule since it binds us to particular materials. Likewise, we can now see that the sort of certainty here being discussed is possible within physics as well as metaphysics. Efficient causes, which are the province of physics, are sometimes sufficient conditions for their effects. Material causes, which are also the province of physics, are not. The materials that make up water, for example, are not by themselves enough to guarantee the existence of water; they can take other forms.

At this point it should be clear that the certainty related to forms is not epistemic certainty. Universal predication and the specification of sufficient conditions have little to do with the conclusiveness or lack thereof of evidence or an argument. “X is a sufficient condition of Y,” even if true, may remain unproven. And if it is not known conclusively, then it is epistemically uncertain even though the rule that we might infer from that statement would be certain in the sense described above.

What are we to make of this? Does the certainty of forms have anything at all to do with any of our familiar uses of the term ‘certain’? This question is important. Unless I can account for Bacon’s choice of the term, one might want to resist my reading. Indeed, Bacon himself seems to suggest that he has epistemic certainty in mind. In stating the rule for generating heat, he says that the phenomenon of heat follows “without doubt” (*proculdubio*) when the formal cause is present.⁷⁵ The point appears to be not just that we happen not to doubt that the phenomenon of heat will follow—that is, he is not appealing to psychological certainty—but that heat is guaranteed to follow as a matter of fact. There is no doubt that it will follow. It is, one might think, epistemically certain that if the formal cause is present, the phenomenon will be present.

I reject this reading, so I am obligated to provide an alternative account of

⁷⁵N.O. II. 20.

Bacon's choice of the term "certain" and his reference to the fact that phenomena follow "without doubt" when the formal causes of them are present. "Certain" can also mean determined, fixed, or settled, and we might try to retreat to this broader definition of the term. Is there a sense in which axioms that are certain are settled or fixed? First of all, they are not necessarily unchanging. If an axiom is certain but too narrowly restricted to particular materials, we may indeed need to revise the axiom. Furthermore, uncertain propositions do not necessarily have to fluctuate or be unstable. An uncertain proposition is one in which the predication does not always hold, but holds either for the most part, incidentally, or not at all. For example, for the most part summer days are hot. The nature, heat, is predicated of most but not all summer days. Thus, being a summer day is not a sufficient condition for the presence of heat. Note, though, that there is no reason why such an uncertain proposition should be any less fixed than a certain one. It might be true now and for all time that summer days are for the most part hot.

Another possibility is that propositions are called certain or uncertain derivatively. One way in which this could be so is if what is epistemically certain is the conclusion of an inference, such as the inference from this being a summer day to this being a hot day. If we know that this coming Sunday is going to be a summer day and that summer days are for the most part hot, then we cannot conclude with certainty that this coming Sunday is going to be hot. Note that "Summer days are for the most part hot" could be epistemically certain, but it would be described by Bacon, according to this hypothesis, as uncertain (in a non-epistemic sense) in virtue of the epistemic uncertainty of conclusions derived from it about any particular summer day.

Although I suspect that this hypothesis partly explains Bacon's terminology, there is still some awkwardness here. If the conclusion of the inference is the primary bearer of the property of certainty, why doesn't Bacon just speak that way? The answer, I suspect, is that Bacon is using the term "certain" in a technical sense taken from, or at least influenced by, his reading of Aristotle in Latin translation. As we have seen from our discussion of moral certainty, the Greek *akribeia*, meaning exactness or precision, was conventionally translated with the

Latin *certitudo*. Thus, Bacon would have been aware of a number of places in Aristotle's corpus where he appears to discuss certainty. Since, as we will see, Aristotle himself associates *akribeia* with universal predication, the simplest explanation of Bacon's usage is that he is following Aristotle, as filtered through a rather inadequate Renaissance translation.

Aristotle's most well-known discussion of *akribeia* occurs in the *Nicomachean Ethics*: "One would speak adequately if one were to attain the clarity [*diasaphethein*] that goes along with the underlying material, for precision [*akribes*] ought not to be sought in the same way in all kinds of discourse."⁷⁶ Aristotle explains that sometimes good things such as courage lead to harmful consequences. Universality, therefore, cannot be demanded of ethics. "So one ought to be content, when speaking about such things and reasoning about such things, to point out the truth roughly and in outline, and when speaking about things that are so for the most part, and reasoning from things of that sort, to reach conclusions that are also of that sort." Here Aristotle associates *akribeia* with universal predication in the same way that Bacon associates certainty with universal predication. Aristotle is not done, however, for he continues by associating imprecision with "probable conclusions" and precision with demonstrations, and this association may explain the mistranslation of *akribeia*.⁷⁷ The connection seems to be the one I suggested just above when discussing the relationship between universally predicated propositions and the certainty of conclusions derived from them. If summer days are for the most part hot, and if this coming Sunday will be a summer day, then we can conclude merely that this coming Sunday will probably be hot. Since not all summer days are hot, there is a chance that this one will not be. On the other hand, if all triangles have an angle sum equal to two right angles, and if ABC is a triangle, then we can demonstrate with certainty that (as long as the premises are true) the angle sum of ABC is equal to two right angles. Since this property holds of all triangles, it must also hold of this particular triangle. The certainty or uncertainty of the conclusion derives not only from the epistemic certainty of the premises, but also from the universality or non-universality of the major premise.

⁷⁶Aristotle, *Nicomachean Ethics*: 1094b11.

⁷⁷Ibid.: 1094b24.

An epistemically certain conclusion requires both the universality and epistemic certainty of the premises. Without universal premises, the particular instance under consideration might be an exception. Without epistemically certain premises, their probable status is transmitted to the conclusion.

The upshot of this discussion of the certainty stemming from our knowledge of forms is that many commentators on Bacon have been misled. When discussing Bacon's attitude towards certainty, they have latched onto forms as the bringers of epistemic certainty. They hold that nothing is epistemically certain in the first five parts of the *Instauratio* but that truths become more highly confirmed as one edges closer to Part Six.

In fact, as I have argued, when Bacon makes a connection between certainty and forms, he only means to say that the nature under investigation must be universally predicated of the form, and that if we succeed in stating a formal cause, we will be able to derive an exception-free rule of operation. Note that it is not even quite right to read II. 4 as ascribing certainty to forms or to statements of what the forms are. The certainty relevant there belongs to rules of operation, and forms are sought because they allow for the derivation of the desired kinds of rules.

If epistemic certainty is relevant here at all, it is because of the certainty of the conclusions derived from the desired rules, insofar as they are universally predicated propositions. This must be what Bacon has in mind when he says that a nature is present "without doubt" when its formal cause is present. But the conclusions derived from axioms concerning forms cannot be epistemically certain unless we are first epistemically certain that we have properly identified the forms. Thus, there is nothing distinctive about statements of forms or rules of operation that would make them certain but natural history uncertain. Epistemic certainty is a matter of the conclusiveness of evidence, and Bacon's account of the certainty of rules of operation provides us with no reason to expect that conclusive evidence is possible only at the *Instauratio's* culmination. Because of Bacon's attack on Academic skepticism, we have reason to think that he regards epistemic certainty as a possibility (although I have not yet adjudicated between the different

possible conceptions of epistemic certainty, such as the *scientia* conception and the indefeasible justification conception). The question therefore remains: which items of knowledge, during which stages of the scientific process, can attain epistemic certainty? As we will see in the next chapter, Bacon holds that epistemic certainty is available from the very start, beginning with sense-perception, which serves as the foundation for everything else.

Chapter 3

The Certainty of Sense-Perception

One reason to care about Francis Bacon's account of sense-perception is the fact that qualms about sense-perception often feed into skepticism about scientific claims. When some philosophers try to explain how we could be wrong about some of our most well-confirmed generalizations and predictions, they sometimes fall back on the possibility that our senses are deceiving us. If the senses might be giving us misinformation (if, for example, there is a Cartesian evil demon or we are hallucinating or dreaming), then all empirical claims about the world are radically mistaken. This is one reason Descartes targets beliefs derived from the senses at the opening of the *Meditations*. By challenging those beliefs, he can undermine most of our other beliefs (before beginning to rebuild science on a firmer foundation). It is also worth noting that some contemporary philosophers list the belief in the veridicality of the senses as an auxiliary assumption employed in our confirmation and disconfirmation reasoning. Does the skeptical worry that our sense-perceptions might be false not arise for Bacon? If not, why not? How does he defend their certainty, and how does he reconcile that certainty with his tendency to disparage the senses for their faults and weaknesses? These are the questions to be addressed in this chapter. I will show that Bacon has good reasons for thinking that sense-perception can serve as a reliable foundation for the natural historical work that is to follow.

A related task for this chapter is to resolve an apparent tension in Bacon's discussions of sense-perception. On the one hand, Bacon is clear that sense-perception plays a fundamental role in the construction of a "sacred shrine to the pattern of the world," in that "all Interpretation of Nature starts from sense, and leads from perception of the senses by a proper, straight and secure route to the perceptions of the intellect,"¹ and he even goes so far as to call himself a "high priest of the sense [*Antistites religiosos*]."² He is also critical of skeptics for undermining the certainty of sense-perception, and his criticisms make little sense unless he regards sense-perception as certain. On the other hand, he refers to errors, faults, desertions, and deceptions of the senses, including certain deceptions—those stemming from the relational nature of sense-perception—which he describes as great or grand [*magna*].³

My contention is that it is by adhering to an Epicurean account of the senses that Bacon can recognize these faults while still justifiably regarding sense-perception as a reliable foundation for natural history. More specifically, Bacon follows in the footsteps of the Epicureans in his answers to four crucial questions about sense-perception:

1. What are the immediate objects of sense-perception? Bacon holds that they are mind-independent, thereby avoiding the problematic inference from sense data to the world that is required by representationalists.
2. What is the relationship between reason (*logos*) and sense-perception? Bacon holds that the reports of sense-perception are *alogos*, or non-notional and non-propositional. This is important because it means that the so-called faults of the senses are merely necessary conditions of some kinds of *intellectual* errors. Properly speaking, then, the mind is responsible for the errors in question. Sense-perception itself, since it is *alogos*, does not make errors and is neither true nor false in the propositional sense.
3. What is the epistemological status of the reports of sense-perception about

¹*N.O.* II. 38.

²*Distributio operis*, D5^v 8.

³*N.O.* II. 40.

the world? Here Bacon accepts the controversial Epicurean thesis that all sense-perceptions are true. By this he means that they register mind-independent objects or qualities—that is, whenever sense-perceptions vary or change, there is some corresponding variation or change in the world. The so-called faults and deceptions of sense-perception are not exceptions to the thesis that all sense-perceptions are true, when “truth” is thus defined.

4. What are the consequences of withholding assent to the reports of sense perception about the world? Bacon believes that withholding assent would render *scientia* impossible.

Bacon’s answers to these questions, since they depend on what must for Bacon be an *a posteriori* account of sense-perception (or on pragmatic considerations in the case of the fourth question), should not be construed as a *refutation* of the skeptic about sense-perception. Indeed, Bacon never says that he can refute the skeptic. I characterize them instead as a way of *defusing* skeptical arguments or, in other words, of showing that their doubts about sense-perception are unreasonable. So when Bacon implies that sense-perception is certain, it is most charitable to take him to mean that all sense-perceptions are true beyond a reasonable doubt and, in particular, that they are not vulnerable to the arguments offered by skeptics. This points us towards the indefeasible justification conception of epistemic certainty mentioned in the previous chapter. However, Bacon cannot *prove* that all sense-perceptions are true. Given this limitation of Bacon’s defense of sense-perception, it is reasonable to wonder whether the senses remain uncertain in the way that is most at issue in this context, i.e., whether is possible, as far as our evidence is concerned, that sense-perception is sometimes or always false. I will be in a better position to address that concern at the end of the chapter. Let us first take each of the above questions in turn.

3.1 What are the Immediate Objects of Sense-perception?

By an immediate object of sense-perception, I mean whatever is included in the content of sense-perception itself—the thing that sense-perception is about—such that our awareness of it does not depend on our working upon, modifying, or inferring anything from sense-perception.⁴ It is what we are directly aware of. Most generally, the question is whether these immediate or direct objects are internal or external, i.e., mind-dependent or mind-independent.

Identifying the basic nature of these immediate objects is important. If they are mind-dependent, then Baconian natural history, which is supposed to contain information about the world that we gather ultimately from sense-perception, will require a problematic inference from our mental contents to the outside world. If they are mind-independent, then our cognitive access to the world is direct. Combined with the view that all sense-perceptions are true (to be addressed in 3.3), this would imply that sense-perception always provides us with true information about a mind-independent world.

Much of what we can infer about Bacon’s account of sense-perception comes from how he tries—sometimes explicitly and sometimes implicitly—to align himself with some ancient schools and to distinguish himself from others. Therefore, we need to situate Bacon within the ancient debate about sense-perception as he saw it.

⁴The term “immediate object” is not used by the ancients, as far as I know, but they do seem to have an idea of something that fits this description. In the context of Berkeley’s thought, Samuel Rickless claims that mediate perception is perception via an intermediary (i.e., one perceives the mediate perceived object by first immediately perceiving some prior object), while immediate perception is perception without an intermediary. While this may be Berkeley’s understanding, I am troubled by the negative definition of “immediate object.” I want to know what an immediate object is, not just what it is not. I am also worried about the *prima facie* circularity in this definition of ‘mediate perception.’ That definition makes reference to ‘immediate perception,’ which is itself defined as the negation of mediate perception. An unassailable positive definition of ‘immediate perception’ proves difficult, though, so I think it may be impossible to define. What one can do (and I suspect that this is the most one can do) is talk about it in a way that allows someone to grasp it ostensively, and I hope that I have done at least that. See Rickless, *Berkeley’s Argument for Idealism*: Ch. 1.

3.1.1 Ancient Views

Let me start with a word about Bacon's sources. We know that Bacon draws on Diogenes Laertius' *Lives* for information about the ancients, including Pyrrho, Democritus, and Epicurus, and the influence of Lucretius' *De rerum natura* on Bacon is well-known.⁵ Book X of the *Lives* includes the Letter to Herodotus and the *Kuriai Doxai* (Principal Doctrines), both of which include important material on Epicurus' account of sense-perception. Bacon also demonstrates an acquaintance with Stoic epistemology. A possible source here is Cicero's *Academica*, which presents a critique of Stoic epistemology from the perspective of Academic skepticism, and also contains some highly dismissive discussions of Epicurus, which must be approached with a grain of salt.⁶ We do know that Bacon was acquainted with fragment 20 of the *Academica*, preserved by Augustine in *Contra academicos*, since he paraphrases it in the *De augmentis*.⁷ Since Augustine gives some indication of the contents of the *Academica*, Bacon would have been familiar with it indirectly if not directly.

There are a couple of prominent skeptical works which I will ignore. Although Bacon may have read Montaigne's *Apology for Raymond Sebond*, the discussion of the senses therein does not substantially differ from the Pyrrhonian view as expressed in Diogenes' *Life of Pyrrho*, so I will focus on the more certain source, which is the latter. And since there is no compelling evidence that Bacon was directly acquainted with the works of Sextus Empiricus, I will also set aside his works.⁸ And lastly, although I will not refer to Democritus' fragments (and although Democritus would disagree with some of the claims that I will attribute

⁵See, for example, Schuler, "Francis Bacon and scientific poetry": pp. 34-41; Johnson and Wilson, "Lucretius and the History of Science": pp. 134-5. For a discussion of the extensive influence of Lucretius on Bacon's *De sapientia veterum*, see Lemmi, *Classic Deities in Bacon: A Study in Mythological Symbolism*. For a discussion of the extent of Bacon's atomism, see Rees, "Atomism and 'subtlety' in Francis Bacon's philosophy".

⁶Interest in Cicero's *Academica* surged in the latter part of the sixteenth century. I know of no sure evidence that Bacon read the work, but it would not have been difficult for him to do so. See Schmitt, *Cicero Scepticus: A Study of the Influence of the Academica in the Renaissance*.

⁷Vol. 4, p. 462. The fragment can be found in Augustine, *Against the Academicians and The Teacher*: 3.7.16.58.

⁸I am in agreement here with Eva, "On the affinities between Bacon's philosophy and skepticism": pp. 20-21. Eva cites Granada and Emil Wolff as sharing this view.

to the atomists) differences within the atomist school will not matter much for our purposes because Bacon frequently conflates Democritus, Epicurus, and Lucretius and appears to think that the *De rerum natura* is primarily a defense of Democritus, when in fact its more immediate inspiration is Epicurus.⁹

Let us now turn to the views one would find in these sources about the nature of the immediate objects of sense-perception. The Pyrrhonians and the Academics hold that internal mental representations are the immediate objects of sense-perception. The Stoics resemble modern disjunctivists; in cases of veridical sense-perception, the object is external, while in cases of non-veridical sense-perception, the object is nothing but a mental image. The atomists are widely interpreted as direct realists, but interpretations are varied and fall into at least four categories. The immediate objects are said to be either internal mental representations (this view thus denies that they are direct realists),¹⁰ *eidola* or thin films of atoms that strike the sense organs,¹¹ or solid physical objects at a distance from the perceiver¹²—but there can also be hybrid views which argue that there is more than one kind of intentional object.¹³ Since there can be a legitimate debate about which of these schools, if any, Bacon follows, I will discuss each one of them in turn.

That the Pyrrhonian skeptics hold that the immediate objects are mental representations is suggested by what they take to be evident in their arguments. According to Diogenes, they hold that what is evident is the criterion: “In like manner, Zeuxis, a friend of Aenesidemus, in his treatise on *Twofold Arguments*, and Antiochus, of Laodicea, and Apellas, in his *Agrippa*, all declare nothing beyond what is evident. The criterion therefore, among the [Pyrrhonian] Sceptics, is that which is evident; as Aenesidemus also says; and Epicurus says the same thing.”¹⁴ And when you look at what they take to be evident in their arguments, our mental

⁹Bacon refers to the *De rerum natura* as an expression of a single school of thought belonging to both Democritus and Epicurus, but he refers to the ideas as Democritean most frequently (e.g., in the very subtitle of his *De principiis atque originibus*).

¹⁰Cf. Long, “Aisthesis, prolepsis and linguistic theory in Epicurus”: p. 116.

¹¹Cf. Everson, “Epicurus on the Truth of the Senses”: p. 177.

¹²Cf. Glidden, “‘Sensus’ and Sense Perception in the ‘De rerum natura’”.

¹³Cf. Everson, “Epicurus on the Truth of the Senses”: p. 181.

¹⁴“Pyrrho” in Diogenes Laertius, *The lives and opinions of eminent philosophers*: p. 11.

representations seem to be included. They never question that an apple *appears* sweet or red; they use these appearances as premises, arguing that because it appears sweet to one person and bitter to another, we have no more reason to believe that it is one way rather than the other. The thought is that our mental representations are exactly as they seem to be, even though the world might not be exactly as it is represented to be. This suggests that the immediate objects of sense-perception are mental representations and that we go beyond the immediate objects when we make claims about the external world.

The Academic view, which is similar, can be found in Cicero's *Academica*. That the Academics are committed to the claim that the immediate objects of sense-perception are internal mental representations is clear from their endorsement of the following theses:

1. We experience impressions or images.
2. True impressions are those which represent the world accurately, while false impressions are those which misrepresent the world.
3. For any true impression, there is a possible false impression with identical sense-content—that is, with identical immediate objects.¹⁵

Since the immediate object of a true impression is the same as the immediate object of a false impression, and since the only element common to the two cases is the character of the impression itself, that impression must be the immediate object.

The Stoics agree with theses (1) and (2) above, but they reject (3).¹⁶ Introducing the term “apprehension” (*katalepsis*), which refers to a mental state, whether perceptual or conceptual, in which we grasp the way things really are, they argue that some, but not all, perceptual states are *kataleptic*. They admit that illusions, dreams, hallucinations, and the like are *akataleptic*.¹⁷ In these cases, we still know the way things seem, but not the way things really are. But how do

¹⁵Cicero, *On Academic Scepticism*: 2.83.

¹⁶Ibid.

¹⁷Ibid.: 2.19.

we know when the senses are apprehending things and when they are not? There must be a mark, they say, that is distinctive to cases of genuine perception. This means that for any given *kataleptic* perception, there is no phenomenologically identical mental state that is not also *kataleptic*. Dreams have a dreamlike quality and hallucinations a hazy quality, whereas genuine perception is clear and distinct. To grasp external things, then, we must pay attention to the distinguishing mark that belongs to genuine perception. In other words, we have to scrutinize our impressions, rather than work upon, modify, or infer anything from them. Thus, the Stoics hold, like present day disjunctivists, that when we have a false impression, the immediate object is merely an internal mental representation, whereas when we have a true impression, there is an external immediate object. In the former case there is no apprehension or grasp of an external object; in the latter case, there is.

The atomist view is comparatively difficult to decipher and has been the subject of some debate. If Bacon put much weight on Cicero's characterization of Epicurus, he might have inclined toward the mental representation interpretation. Cicero characterizes Epicurus as if his sole point of disagreement with the interlocutors would be with their claim that some sense-perceptions are false. Moreover, Lucullus says that Epicurus "claims that everything is exactly as our impressions represent it," thus suggesting that impressions are the immediate objects and that the character of external things is inferred to be just like them.¹⁸ Epicurus does talk about impressions or sensory presentations (*phantasiai*) on occasion in the reports by Diogenes,¹⁹ but it is not clear whether these are to be understood as internal, intentional objects. The mere claim that objects appear or are presented to us a certain way—that a tower has a round appearance, for example—doesn't mean that the appearances are the immediate objects of sense-perception, and there are philosophical reasons for thinking that this cannot be the atomist view, as I will discuss in a moment.

Stephen Everson has argued that the atomists hold that the *eidola* are the

¹⁸Ibid. Cicero uses *visum*, *visio*, and *quod videri* as translations for the Greek *phantasia*.

¹⁹For example, see Section 50 of the "Letter to Herodotus" in Epicurus, *The Epicurus Reader: Selected Writings and Testimonia*.

immediate objects of sense-perception:

By taking the objects of perception to be the *eidōla* rather than the solid objects, it is possible to see why Epicurus should claim that different senses do not discriminate the same things, since the atoms emitted by solid objects will only be able to affect one sense: each sense is responsive to a different type of atomic emission. More importantly, perhaps, we can now make sense of Epicurus' otherwise very puzzling claim that the perceptions we have in dreams and hallucinations are true.²⁰

Everson's argument is based on two important atomist theses. First, one sense cannot be used to refute another sense because they discriminate different things. For example, when the sense of sight discriminates a bend in a submerged oar, whereas the sense of touch discriminates no such bend, the two senses are not actually in conflict because the former is telling us about a visual property while the latter is telling us about a tactile one. Second, as I will discuss in more detail below, all sense-perceptions, including hallucinations, are true. According to Everson, it is difficult to make sense of these theses if remote, physical objects are the objects of perception. If truth requires (as Everson thinks it does) some kind of match between the reports of the senses and the objects of the senses, then the *eidola* must be the objects. Whether we are dealing with allegedly conflicting appearances of submerged oars or with hallucinations, the *eidola* are the candidates for immediate objects which would most plausibly provide such a match—so Everson argues.

It is not in question, of course, that the atomists hold that *eidola* or effluences stream off of physical objects, sometimes becoming distorted during their journey, and, by impacting the sense organs, give rise to our mental representations. However, the fact that *eidola* are *causal* intermediaries between physical objects and the resulting mental representations does not imply that they are also perceptual intermediaries. In other words, there is a difference between the means of sense-perception and the objects of sense-perception, and by and large the textual evidence supports the claim that *eidola* are among the means, not the objects, of sense-perception. The point of the atomists' discussing this causal mechanism is to reassure us that some orderly and rationally comprehensible process gives

²⁰Everson, "Epicurus on the Truth of the Senses": p. 177.

rise to what we perceive, not to identify the objects of sense-perception. Even if Everson is correct that truth requires a match between a perception and its object, the atomists could just as well intend to offer up this account of the mediation of *eidola* as an explanation of the way in which perceptions match up with remote, physical objects.

In addition, there are reasons for thinking that the physical objects, rather than *eidola*, are the immediate objects of sense-perception. Most compellingly, there is this passage from Lucretius:

In this connection, you should not consider it strange that, although the images that impinge on our eyes are individually invisible, the objects themselves are visible. After all, when the wind whips us with fitful blasts, and when biting cold flows upon us, we do not feel the individual particles of wind or cold, but rather their combined effect; and we then perceive that blows are falling upon our body, just as if some external force were whipping us and giving us the sensation of its body. Moreover, when we tap a stone with a finger, what we touch is merely the superficial layer of color on the outside of the rock; but what we feel, when we touch the rock, is not its surface color, but rather the hardness deep down within it.²¹

If *eidola* were the immediate objects of sense-perception, then they would have to be visible (or audible, etc.), whereas physical objects, strictly speaking, would not be, since we never actually come into contact with them. That seems to be the opposite of what Lucretius says here. In fact, implicit in the passage above seems to be the distinction between causal intermediaries of various kinds and intentional objects.

Furthermore, the atoms are colorless, tasteless, and odorless; all the variety in their appearance depends on their shapes and configurations. The *eidola* have color but still lack many other qualities. This is a problem for the *eidola* interpretation, which owes much of its plausibility to its attempted explanation of the atomist view that all sense-perceptions are true. Now it seems that even *eidola* do not perfectly match our mental representations in the way Everson wants.

So on my interpretation, as well as the one that I think Bacon would have been most likely to adopt (since some of Everson's best evidence comes from Sextus

²¹Lucretius, *On the Nature of Things*: 4.255-68.

Empiricus, whom Bacon probably did not read), we immediately perceive physical objects and their qualities. When we see a tower, we really see that tower. There is a causal explanation, involving the distortion of *eidola* and their interaction with the sense organs, for how we see the tower and why it appears the way it does, but the causal intermediaries are not the objects of sense-perception—and indeed they can easily go unnoticed.

3.1.2 Bacon's View

What, according to Bacon, are the immediate objects of sense-perception? In answering this and other questions about Bacon's account of sense-perception, I will rest part of my case on Bacon's general affinity for (though not always full agreement with) atomism. And even though we cannot always be certain how Bacon interpreted the atomists, we can be certain that he wrestled with their arguments and appreciated the problems that they faced and tried to solve.

The influence of Lucretius on Bacon is well-trod ground. For example, Graham Rees has pointed out that in spite of Bacon's rejection of the kind of void embraced by the atomists, he shares their belief in the epistemic importance of microscopic processes.²² But so far, nobody has argued that Bacon's account of sense-perception is thoroughly atomist. A secondary goal of mine in this chapter is to argue for a more expansive understanding of the atomist influence on Bacon.

Like the atomists, Bacon is committed to the existence of external objects, effluences,²³ and sensory impressions or presentations.²⁴ But which of these are the immediate objects? I argue that he holds that external things are the immediate objects. The emissions of objects and their impressions are merely causal intermediaries rather than intentional objects of sense-perception. In this section, though,

²²Rees, "Atomism and 'subtlety' in Francis Bacon's philosophy".

²³Bacon terms them "transmission of spirits and imagination" and divides them into two categories: transmission of the thinner parts, which gives rise, for example, to odors, and transmission of the spiritual species, which gives rise to visible forms. *Sylva sylvarum* in Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 2, pp. 903-5. Cf. p. 268: "The species of visible seem to be emissions of beams from the objects seen; almost like odours; save that they are more incorporeal: but the species of audibles seem to participate more with local motion, like percussions or impressions made upon the air."

²⁴*N.O.* I. 69.

I will only offer an interpretation of Bacon's view concerning the immediate objects of *veridical* sense-perception. I will rule out a Stoic interpretation of Bacon in 3.3, when I argue that Bacon holds, contrary to the Stoics, that all sense-perceptions are true. If all sense-perceptions are true, then there is no need to assign a different kind of object to cases of non-veridical sense-perception. The indistinguishability of true and false perceptions is the whole motivation for a disjunctivist account.

One piece of evidence that Bacon is a direct realist at least as regards veridical sense-perception is the following passage, which comes in the context of his explanation of his table of degrees:

For since the form of the thing is the very thing itself, and the thing does not differ from the form in any way other than appearance from existence, external from internal, or that relative to man from that relative to the universe, it inexorably follows that no nature can be taken for the true form unless it always diminishes when the nature itself diminishes, and likewise always increases when the nature itself increases.²⁵

This passage asserts that there is an analogy between two groups of items:

The thing	The thing's form
Appearance	Existence
External	Internal
Relative to man	Relative to the universe ²⁶
Effect	Cause ²⁷

The idea here, used to justify the employment of the table of degrees, is that each pair represents two aspects of the same thing, so that changes in the right

²⁵*N.O.* II. 13.

²⁶This distinction is formulated in a few different ways: there is what is relative to man or sense (*ex analogia hominis* at *N.O.* I. 41, II. 40 2L3^r11, *in ordine ad hominem* at *N.O.* II. 20, or *relativus ad Sensum* at *N.O.* II.20 2B1^r1, 2B4^r23.) and there is what is relative to the universe (*ex analogia universi* at *N.O.* I. 41, II. 40 2L3^r11 or *in ordine ad universum* at *N.O.* II. 20. 2B1^r1, 2B4^r23.

²⁷I am adding this pair to the list on the basis of *N.O.* II. 20, 2B1^r1. "As far as sense goes, heat is a respective thing, and relative to man, not to the universe; and it is rightly set down that heat is just its effect on the animal spirits."

column should result in corresponding changes in the left column. We should be struck by how unusual this argument is. We tend to think of things that are apparent and merely relative to us as internal, as mental representations inside us. Here, however, appearances correspond to the external—that is, they are outside or at least on the surface of the thing that is being investigated—and forms correspond to the internal—to the inner, unseen parts of bodies. Therefore, when Bacon talks elsewhere about appearances, or about that which is relative to man, we should not assume that he is talking only about mental representations (although these might be included). Bacon holds, for example, that even though the objects around us are in reality always in flux, they appear largely stable and unchanging.²⁸ Yet it seems philosophically implausible to say that our impressions are unchanging. When I look around the room, my impressions change from moment to moment, though the desk in front of me seems stable. So appearances should not be equated with impressions, and even if what we immediately perceive is always some appearance, direct realism is not ruled out. The qualities that we perceive can be both apparent and external to the mind.

Bacon's natural histories help confirm that the immediate objects of sense-perception are external to the mind. In the *De augmentis*, he notes that history takes the individual things that impress themselves on us via the senses and calls them up again. "History is properly concerned with individuals," by which he means to refer to individual, external objects.²⁹ And indeed, when we look at the tables concerning heat in the *Novum organum*, we find "fiery meteors," "thermal baths," "horse dung," and, in short, a collection of things that are clearly external to the mind.³⁰ Bacon does not attempt to start with merely internal sensations; the reports in his natural histories would be bizarrely unjustified unless direct realism were presupposed, at least for veridical cases.

²⁸*N.O.* II. 48, 2R2^v 5.

²⁹Vol. 4, p. 292.

³⁰*N.O.* II. 11.

3.2 What is the Relationship Between Reason and Sense-perception?

In this section, my focus is on the Epicurean view that sense-perception is *alogos*. That thesis is an important component of the Epicurean response to skepticism and turns out to be part of Bacon's response as well. The idea is that because sense-perception is non-notional and non-propositional, our erroneous judgments about the world, which are notional and propositional, must not be directly rooted in sense-perception. Any errors involve acts of the intellect.

3.2.1 Ancient Views

The Epicureans hold that there is an important distinction between sense-perceptions and opinions. Every sense-perception (*aesthesis*), Diogenes reports Epicurus as holding, "is unreasoning [*alogos*] and incapable of remembering. For neither is it moved by itself nor can it add or subtract anything when moved by something else."³¹ This passage offers the passivity of sense-perception as evidence for its arationality. Whenever we hold some opinion on the basis of sense-perception, we do not remain merely passive. If, upon seeing a tree, we opine that there is a tree in front of us, we are adding something to our sense-perception. Through such activity error first becomes possible.

The full import of the thesis that sense-perception is *alogos* often went unappreciated by the critics of the Epicureans. Stoics and skeptics alike maligned Epicurus for his supposedly blind faith in the senses, as evidenced by his claim that the Sun is just about the size it appears to be, even though this claim is the result of an argument, not of blind faith.³² As Lucretius puts it:

The wheel of the sun and the heat that it emits cannot be much greater

³¹ "Introductory report of his views" in Epicurus, *The Epicurus Reader: Selected Writings and Testimonia*: 10.31.

³² Cicero is particularly harsh in the *Academica*: "Epicurus, however, thinks that [the Sun] could be a bit smaller than it seems, but 'not much'—though in fact he thinks that it is either exactly as, or not much bigger than, it seems, so that his eyes aren't deceiving him at all, or 'not much'! [...] But let's leave the gullible Epicurus to think that the senses never deceive." Cicero, *On Academic Scepticism*: 2.82.

or less than they seem to our senses. For, no matter how distant a fire is, as long as it can project its light on us and breathe a hot blast on our limbs, its size is not diminished at all by the intervening distance: there is no perceptible contraction. Therefore, since the sun's heat and lavish light reach our senses and irradiate the terrestrial regions, it must be assumed that the form and contour of the sun are seen from the earth in their true dimensions with absolutely no enlargement or diminution.³³

Here he infers the size of the sun by using an analogy to fire. Since a fire's apparent size does not change much with changes in distance, as long as we stay close enough to feel the heat, we have reason to think that the Sun's apparent size would not change much within its sphere of influence either. Since we are clearly within the Sun's sphere of influence, we must be close enough to it such that its apparent size isn't affected by the distance. This argument may or may not be very plausible, but what is not in question is that there is a process of inference here. Sense-perception, by itself, does not tell us the actual size of anything, and in general the contents of sense-perception by themselves cannot be put into propositional form.

The atomists' view can get much more complex once you delve into the exact nature of the inference from sense experience to the properties of objects, but that need not concern us here. The essence of the view, for our purposes, is captured by Lucretius when he says that "the eyes cannot take cognizance of the real nature of things. Refrain, then, from foisting on the eyes the shortcomings of the mind."³⁴ If we make mistakes about the nature of objects, we should blame the inference, not the senses, which inform us only of the apparent properties of objects.

3.2.2 Bacon's View

Bacon agrees with the atomists that sense-perception is *alogos*. The content of sense-perception is neither notional nor propositional since even the most primitive notions must be abstracted from sense experience. Prior to the operation of

³³*On the Nature of Things*, 5.564-73.

³⁴*Ibid.*: 4.385.

reason, there is an awareness of objects, but there are no notions of those objects and no beliefs about their natures.

Although Bacon never explicitly formulates this thesis that sense-perception is *alogos*, he has ways of speaking that suggest it. What Bacon says is that sense-perception is *uninterpreted* until reason comes in and offers an interpretation. One way of understanding this point is through a comparison to Biblical interpretation. There is a close analogy between sense-perception and divine revelation, according to Bacon. “The knowledge of man is as the waters. Some waters descend from above, and some spring from beneath; and in like manner the primary division of the sciences is to be drawn from their sources; of which some are above in the heavens, and some here below. For all knowledge admits of two kinds of information; the one inspired by divine revelation, the other arising from the senses.”³⁵ Just as divine revelation gives us information about the heavenly world, so sense-perception gives us information about the world around us.

In neither case does that information come already interpreted. “Since the Holy Scriptures are the principal sources of information in theology, we must especially look to their interpretation.”³⁶ (The proper interpretation, he adds, is often neither literal, obvious, nor even contextual. That is, it might be proper to take passages, sentences, and even words out of context and to imbue them with new, perhaps personal meaning, as was done, for example, in the practice of *Sortes Sanctorum*, in which one turns to a random passage of scripture in order to divine God’s will.) Similarly, Bacon calls his inductive method the “interpretation of nature.” In both cases, reason can interpret the evidence, whether scriptural or perceptual, rightly or wrongly. We might go wrong, for example, if we judge based on scripture that God has hands and feet, or if we judge based on the evidence of sense-perception that an oar submerged in water is bent. We might even say that we are sometimes misled by scripture or by sense-perception. We have to remember, though, that in themselves, the sources of information lack an interpretation. (And since we have the means to interpret the submerged oar as evidence of the refraction of light, error is not inevitable here.)

³⁵*De augmentis*, Vol. 4, p. 336.

³⁶*De augmentis*, Vol. 5, p. 116.

The thesis that sense-perception provides us with uninterpreted information implies the thesis that sense-perception is *alogos*. Since the interpretation of sense-perception is a process of forming notions and propositions, to say that sense-perception is uninterpreted is also to say that it is non-notional and non-propositional.

Like the atomists, Bacon uses his version of the thesis that sense-perception is *alogos* to respond to the skeptics. Errors are always to be blamed on poor interpretations, not on the information that is being interpreted. Accordingly, he echoes Lucretius³⁷ when he says in the *De augmentis* that the skeptics who criticized the senses “ought rather to have charged the defect upon the mind—as well its contumacy (whereby it refuses to submit itself to the nature of things) as its errors,—and upon false forms of demonstration, and ill-ordered methods of reasoning and concluding upon the perceptions of the senses.”³⁸ The corresponding passage in the 1605 English version offers an illuminating legal metaphor: “But here was their chief error; they charged the deceit upon the senses; which in my judgement (notwithstanding all their cavillations) are very sufficient to certify and report truth [...] they ought rather to have charged the deceit upon the weakness of the intellectual powers, and upon the manner of collecting and concluding upon the reports of the senses.”³⁹ In the metaphor, the senses are in the position of witnesses supplying reports (certifying and reporting truth), and the mind is in the position of the lawyer who examines the witnesses and formulates arguments on that basis. Bacon compares skeptical arguments against the senses to cavillations, that is, to quibbling, sophistical legal arguments. The problem lies with the lawyer, not the witnesses—with the mind, not the senses. Of course, witnesses can be

³⁷ “[T]he eyes cannot take cognizance of the real nature of things. Refrain, then, from foisting on the eyes the shortcomings of the mind.” Lucretius, *On the Nature of Things*, 4.385.

³⁸ *De augmentis*, Vol. 4, p. 412.

³⁹ Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 3, *Advancement of Learning*, pp. 388-9. The use of the word “reports” might seem to suggest that sense-perception is propositional, but that term reflects the comparison to the reports of witnesses and should not be taken too literally. For further evidence of Bacon’s routine use of legal metaphors for the role of observation and experiment, see Martin, *Francis Bacon, the State, and the Reform of Natural Philosophy*: pp. 164-71. In my view, Martin exaggerates the philosophical significance of these metaphors (he argues that the interpretation of nature is modeled on the procedures of the law courts), but his discussion is nevertheless valuable.

unreliable, and the metaphor would be a poor one if the senses did not offer some parallel to this unreliability. And the senses do offer such a parallel. Like witnesses, sense-perception can mislead, but the blame for being misled always lies with the mind, which is responsible for collecting and interpreting the information from sense-perception.

Other passages are consistent with this tendency to blame the mind rather than the senses. In the *Valerius terminus*, he charges that both schools of ancient Skeptics

did unjustly and prejudicially to charge the deceit upon the report of the senses, which admitteth very sparing remedy; being indeed to have been charged upon the Anticipations of the mind, which admitteth a perfect remedy. That the information of the senses is sufficient, not because they err not, but because the use of the sense in discovering of knowledge is for the most part not immediate. So that it is the work, effect, or instance, that trieth the Axiom, and the sense doth but try the work done or not done, being or not being.⁴⁰

Admittedly, this can be a confusing passage, as it implies that the senses do not deceive but do err, and this is a distinction I will have to wrestle with as this chapter progresses. But the passage does clearly lay the blame for false interpretations on the mind. Similarly in the *Partis instaurationis*, Bacon says that “although the true interpretation of nature, wherein we toil, be justly held most difficult, yet by far the greatest part of that difficulty depends upon what lies within our own power and admits of correction, not on things placed beyond our sphere of capacity; I mean in the mind, not in things, or in the senses.”⁴¹ And consider this early statement in the *Partis instaurationis* of what he will come to call idols of the tribe. “For as an uneven and ill-cut mirror distorts the true rays of things according to its own incurvation of surface; so, too, the mind, subjected to the impression of objects through the senses, in performing its operations, interchanges and mixes up its own nature with that of its objects, so as it may not be implicitly trusted.”⁴² Here, too, it is the mind which is blamed for taking the data of the senses and

⁴⁰ *Valerius terminus*, p. 201.

⁴¹ *Partis instaurationis*, p. 552.

⁴² *Ibid.*: p. 551. cf. N.O. I. 41.

mixing up its own—that is, the mind’s—nature with it. What we need, according to Bacon, is a better method of interpretation.

3.3 What is the Epistemological Status of the Reports of Sense-perception?

From the thesis that sense-perception is *alogos*, it follows that sense-perceptions are neither true nor false in a propositional sense.⁴³ Yet according to some accounts the atomists still want to insist, against both skeptics and Stoics, that all sense-perceptions are true. In this section, I will suggest that what lies behind this contention is the belief that all sense-perceptions, including ones that *others* regard as non-veridical, register or make us aware of mind independent objects or qualities. Then, by looking at Bacon’s account of perception (and at an idea he adopts from the natural magic tradition called “consent”) and at how he handles illusions and hallucinations, I will argue that Bacon embraces this atomist thesis.

3.3.1 Ancient Views

The thesis that all sense-perceptions are true does not appear in the writings of Epicurus that have come down to us. He does say that there would be no errors or falsehoods without opinions that are added to sense-perception, but this claim is compatible with the idea that sense-perceptions are neither true nor false.⁴⁴ A common source for Epicurus’ view is Sextus Empiricus, but I am again setting him aside. This leaves Lucretius, who says that whatever seems to be the case to the

⁴³Gisela Striker has denied this and argued that a sense-perception is true, for Epicurus, if all propositions that express no more and no less than the content of that sense-perception are true. I think this misses the point of the claim that sense-perception is *alogos*. To attach any notion or proposition to a sense-perception, even an obvious one, is already to go beyond the sense-perception itself and requires reason. In other words, there are no propositions that express neither more nor less than the content of a given sense-perception. They necessarily express, and depend on, more. Striker, “Epicurus on the Truth of Sense Impressions”: p. 142

⁴⁴“Letter to Herodotus” in Epicurus, *The Epicurus Reader: Selected Writings and Testimonia*: 10.50-52. Cf. *ibid.*: “Principal Doctrines,” XXIV.

senses is always true,⁴⁵ and Cicero, who expresses the idea in a variety of (often uncharitable and possibly inaccurate) ways.⁴⁶

There has been a lot of debate over what the atomists could mean by saying that all sense-perceptions are true. They cannot mean that they are propositionally true. And they cannot mean, as some have argued, that they are real, for then the thesis would offer no response to skepticism. The atomists also don't seem to hold that the appearances are true when they resemble external objects, whether physical things or *eidola*. When we have a sense-perception of something bitter, for example, there is no external object that has some similar bitterness that can be compared with the appearance. There are just atoms of varying shapes, sizes, and configurations. Furthermore, what seems bitter to one person might seem sweet to another.

To figure out what the atomists mean, we might look at how they defend the thesis. What, in their view, would threaten it? Both Epicurus and Lucretius defend the truth of sense-perceptions by pointing to their causes. In the case of food that tastes bitter to one person but sweet to another, for example, Lucretius notes, “if the food tastes sweet, extremely smooth particles are entering the pores of the palate with caressing touch: if, however, the same food tastes bitter, then rough and barbed particles are penetrating the orifices.”⁴⁷ As long as there is a causal sequence that begins with an external object, it seems, our sense-perceptions register or make us aware of something about the external object and can for that reason be called true. In this case, the bitter sensation registers the rough particles, while the sweet sensation registers the smooth ones. If the same smooth particles, interacting with a sense organ that was in the same state, sometimes caused a bitter sensation and sometimes caused a sweet one, just by chance, then in that case it might be difficult to defend the truth of the sense-perceptions. Our awareness of the world would be compromised. So a true sense-perception is one that causally registers some mind-independent feature of the world, and in this

⁴⁵Lucretius, *On the Nature of Things*: 4.499: “*proinde quod in quoque tempore, verumst.*”

⁴⁶“Everything is exactly as our impressions represent it [or exactly as it appears—DS]” (2.19). “My senses are veracious (*veraces*), he says” (2.79). Cicero, *On Academic Scepticism*.

⁴⁷Lucretius, *On the Nature of Things*: 4.660.

sense, all sense-perceptions are true.

According to the atomists, even illusions, dreams, and, hallucinations are true in this sense. As Diogenes Laertius reports, “the appearances (*phantasmata*) which madmen have and those in dreams are true (*alethe*), for they cause motion [in minds], and what does not exist does not move anything.”⁴⁸ It is tempting to think that *alethe* means real in this context, since the argument seems to be that because the appearances cause motion, they must exist, and that because they exist, they are *alethe*. But it’s not clear why Epicurus would care to assert that the appearances of dreams or hallucinations are real. In the context, Diogenes is reporting about Epicurus’ defense of sense-perception as the criterion; the claim that dreams and hallucinations are real states is hardly relevant to such a defense. Therefore, *phantasmata*, in this context, must refer to the objects that cause the visions (translate it as “envisioned things”):

(3.1)

- (1) Visions (such as hallucinations) are motions that result from a causal sequence that begins with envisioned things.
- (2) Only real things cause motion in the mind.
- (3) Therefore, envisioned things are real things (from 1 and 2).
- (4) A perception is true if and only if it results from a causal sequence that begins with a real thing (based on my discussion above).
- (5) Visions (such as hallucinations) are motions that result from a causal sequence that begins with real things (from 1 and 3).

∴ (6) Visions (such as hallucinations) are true (from 4 and 5).

Lucretius, too, discusses hallucinations and dreams, and his strategy is consistent with this argument. Here is how he handles dreams: “And if, when sleep has

⁴⁸*The Epicurus Reader: Selected Writings and Testimonia*: 10.32.

prostrated our limbs, our mind is awake, the reason is that it is stimulated by the same images [i.e., *eidola*] as when we are wakeful. Indeed it receives such vivid impressions that we really seem to see persons who have departed from life and now belong to death and dust.”⁴⁹ So Lucretius is intent to show that there is a causal sequence, beginning with external things, which gives rise to the visions in dreams. What would it take for a dream to qualify as false? It would have to be either self-caused, caused by something irreducibly mind-dependent (such as a belief or memory), or the result of a non-causal sequence.

3.3.2 Bacon’s View

Bacon, like the atomists, holds that the certainty, and therefore the truth, of sense-perception must be maintained. “[B]y denying the certainty of the senses,” he says, the Academic skeptics “pluck up science from its very foundation.”⁵⁰ I now want to argue that Bacon means roughly the same thing by this as the atomists. Since he too regards sense-perception as *alogos*, he must not hold that it is true in any propositional sense. I will argue that he instead holds that all sense-perceptions register or detect mind-independent objects or qualities and are, in that sense, true. This process of detection involves a certain responsiveness of the sense organs such that there is no change or variation in sense-perceptions unless there is a corresponding change in the world. However, it is possible for there to be changes and variations in objects that do not result in corresponding changes and variations in sense-perceptions. Here there is a close analogy to scientific instrumentation. When a functioning thermometer’s reading varies over time, it is a sure sign of a change in temperature, so we say that the thermometer registers temperature, even if some changes in temperature are not registered by it (because they are too small or outside its range).

Bacon makes this point by drawing on an old tradition that goes back to the Stoics but which Bacon would have come across most often in texts on natural magic. In essence, he gives an atomist gloss on the idea of sympathy (and other

⁴⁹Lucretius, *On the Nature of Things*: 4.758.

⁵⁰*Scala intellectus*, p. 520.

related ideas) and argues that sense-perception is just a special case of sympathetic action. The idea of sympathy, as espoused by Ficino, Paracelsus, Fracastoro, della Porta, and many others, is that objects do not act on one another only by physical contact. Objects at a distance are interconnected. Changes in the heavens can be used to explain the tides or the onset of a syphilis epidemic, a magnet can attract a piece of iron at a distance, and the sun can animate life on Earth. In all such cases there is some passive object, acted on at a distance, which strives to be closer or more akin to the object acting on it. In this sense, according to many of the proponents of this idea, the whole universe is animate. That the oceans strive to be closer to the moon, for example, can only mean that they have some kind of ability to sense, imagine, or conceive of the moon.

Although Bacon draws on these ideas, he is critical of them in their original form. His preface to his unwritten *Historia Sympathiae et Antipathiae rerum* makes it clear what he rejects:

But this branch of philosophy (also known as natural magic) which concerns itself with the sympathy and antipathy of things is pretty corrupt; and, as ever, where diligence has been short, hope has been extravagant. Hope [...] lulls the human intellect to sleep with enchanting talk of specific properties, and occult virtues sent from the heavens, as a result of which men are no longer encouraged or alive to the business of unearthing real causes but give in to idleness of this kind; and then it insinuates and spreads countless fictions like so many dreams.⁵¹

Although Bacon retains some of the language of natural magic, he gives a gloss on that language which is thoroughly atomist in spirit. Gesturing towards the idea that the whole universe is animate, he says that all bodies have the power of perception:

For we see that all natural bodies have a manifest power of perception, and also a kind of choice in receiving what is agreeable, and avoiding what is hostile and foreign. Nor am I speaking only of the more subtle perceptions, as when the magnet attracts iron, flame leaps towards naphtha, one bubble coming near another unites with it, rays of light start away from a white object, the body of an animal assimilates

⁵¹Bacon, *The Instauration Magna: Part III: Historia naturalis*: S3^r.

things that are useful and excerns things that are not so, part of a sponge attracts water (though held too high to touch it) and expels air, and the like.⁵²

These more subtle perceptions do not involve consciousness, and, making a new terminological distinction, Bacon criticizes those who conflate sense and perception when they ascribe sense to the objects in these cases. But these examples do involve some kind of ability to detect the natures of nearby things. Magnets can detect iron, the stomach can detect food, and so on. In short, all objects have the capacity to affect and to be affected, and that is how he comes to define perception:

no body when placed near another either changes it or is changed by it, unless a reciprocal perception precedes the operation. A body perceives the passages by which it enters; it perceives the force of another body to which it yields; it perceives the removal of another body which held it fast, when it recovers itself; it perceives the disruption of its continuity, which for a time it resists; in short there is Perception everywhere. And air perceives heat and cold so acutely, that its perception is far more subtle than that of the human touch, which yet is reputed the normal measure of heat and cold.⁵³

Sense, or sense-perception, is a special case of this phenomenon; it refers to the faculty which not only registers or detects objects so that something can affect or be affected by them, but which in addition presents the results of that causal interaction to consciousness.

Sense-perception is also just a special case of sympathetic action, but again Bacon provides his own interpretation of this concept (he often uses the word “consent” instead of “sympathy,” which expresses the same concept using a Latinate word rather than a Greek one).⁵⁴ Two bodies are in consent not when one strives to be like the other, but when they exhibit some kind of “mutual symmetry of forms and schematisms.”⁵⁵ One kind of consent is the similarity in schematism that enables some bodies to mix easily with each other. But there is also a kind

⁵²*De augmentis*, Vol. 4, p. 402.

⁵³*Ibid.*

⁵⁴“*con*” = together; “*sentire*” = to feel.

⁵⁵*N.O.* II. 50: T2^v 6.

of consent between the sense organs and their objects.⁵⁶

there is no difference between the consents or sympathies of bodies furnished with sense and of inanimate things without sense, save that in the former animal spirit is added to a body so disposed, but in the latter the spirit is absent. Thus there may be as many senses in animate bodies as there are consents in inanimate, so long as there are perforations in the animate body to allow for the animal spirit to disperse itself into a member properly set up, as into a suitable organ.⁵⁷

Although Bacon does not spell out the nature of this consent in any detail, the idea seems to be that the sense organ takes on the nature of the object that is affecting it. Consider the experiment in which lukewarm water feels hot to one hand and cold to another. Bacon can observe that there is no difference, except for the presence of animal spirits in a suitable body, between the performance of this experiment with your hands as against the performance of the experiment with an ice cube and a hot coal. The ice cube will warm up and melt, thus taking on the nature of heat, but the hot coal will cool down, thus taking on the nature of cold or losing the nature of heat. Similarly, the two hands should report different sense-perceptions. One is reporting our way of experiencing what happens to the ice cube, whereas the other is reporting our way of experiencing what happens to the hot coal. That is, one is reporting the taking on of heat, whereas the other is reporting the taking on of cold or the loss of the nature of heat.

The assimilation of sense-perception to these more general ideas of perception and sympathy explains why Bacon can commit to the claim that sense-perceptions are always true; like everything else in the universe, the sense organs causally register the things that act on them. A false sense-perception could exist only if causality were breached—only if there were variations or changes in sense-perceptions in the absence of any variation or change in the world. I take this to be part of Bacon's point when he says in the *Partis instaurationis* that “we do not attach much weight to the immediate perceptions of sense, except only in so far as it manifests motion [*motum*] or change [*alterationem*] in its objects.”⁵⁸ The passage

⁵⁶The idea that sense-perception is a kind of sympathetic action goes back at least to Plotinus. See Emilsson, *Plotinus on Sense-Perception: A Philosophical Study*: p. 48.

⁵⁷N.O. II. 27, D4^r 20.

⁵⁸*Partis instaurationis*, p. 553.

also gestures towards the faults of the senses,⁵⁹ which I will discuss presently, but despite these faults Bacon affirms that the senses do manifest motion or change. To put it another way, the senses are difference-detectors. Because of limits to their sensitivity and range that are recognized by Bacon, there are differences that go unregistered, but when a difference is registered, one can be sure that there is some difference that caused it.⁶⁰

As we see here, Bacon, unlike the atomists, is willing to talk about faults of the senses. But if we survey these faults, we will see that they are not exceptions to the principle that all sense-perceptions are true. Bacon classifies the faults of the senses into two categories: “The impressions of the sense itself are faulty, for the sense both deserts [*destituit*] and deceives [*fallit*] us. But the desertions require substitutions, and the deceptions require rectifications.”⁶¹ When Bacon says that the senses desert us, he means that they do not tell us everything. He classifies these desertions into several categories: “there are many things which escape the sense even when it is properly managed and not obstructed at all, because of the subtlety of the body as a whole, or the minuteness of its parts, or its distance from us, or its swiftness or slowness, or the object’s familiarity, or other causes besides.”⁶² And again, in a similar list, he says:

Now things escape the sense either because of the distance at which the object stands; or because the sense is intercepted by bodies in between; or because the object is incapable of making an impression on the sense; or because the size of the object will not let the impression be carried

⁵⁹In a fuller statement of the passage, it is clear that his main point is about these faults: “In ministration to the senses we shall make mention of three things, first, how a good notion is collected and elicited, and how the testimony of sense, which is ever according to the analogy of man, may be reduced and rectified to the analogy of the universe. For we do not attach much weight to the immediate perceptions of sense, except only in so far as it manifests motion or change in its objects. Secondly, we shall show how those things which baffle the sense, either by intangibility of the entire substance, or by minuteness of parts, or by remoteness of place, or by slowness or celerity of motion, or by habitual familiarity of the object, or otherwise, may be brought under the jurisdiction of sense, and placed at its bar.” Ibid.

⁶⁰Interestingly, it is a consequence of this account that sense-perceptions of so-called secondary qualities are just as true as sense-perceptions of primary qualities. Both motion and change are manifested. If we register a change in color, for instance, then there must be some corresponding change in the world. As we will see in a moment, it might be a change that is internal to our bodies, but that same caveat applies to primary qualities.

⁶¹N.O. I. 69. My translation.

⁶²*Distributio operis*, B5^r.

to the sense; or because the time available is not suited to activating the sense; or the objects impact cannot be endured by the sense; or an object has saturated and taken possession of the sense so much that no room is left for new motion.⁶³

These desertions do not undercut the truth or certainty of sense-perception. The fact that emissions from far away bodies do not register on our sense organs does not mean that impressions nearby also fail to register; the fact that emissions that last only briefly do not register does not mean that emissions that do last sufficiently long fail to register. In general, the fact that the unaided senses do not tell us everything does not mean that they do not tell us what they tell us.

It is a little more tempting to think that the deceptions of the senses, in contrast to mere desertions, are exceptions to the truth of sense-perception. There are two kinds of deceptions of the senses, particular and grand. “For the deceptions of the senses [*Fallaciae Sensuum*] should be held over to the specific investigations concerning sense and the sensible, save for that grand deception of the senses [*magna Fallacia Sensuum*, i.e., those grand deceptions] that sets up distinctions between things according to the measure of man and not according to the measure of the universe.”⁶⁴ The grand deceptions, this passage suggests, are those which result from the fact that sense-perception is relational, from the fact that we perceive the effects of objects on us rather than their intrinsic natures. Thus, one grand deception is the classic experiment in which lukewarm water can be made to feel hot to one hand and cold to the other. “As far as sense and touch goes, heat is a variable and respective thing, such that to a cold hand lukewarm water feels hot, and to a hot one it feels cold.”⁶⁵ There is no threat to the truth of sense-perception here. When a thermometer registers heat, the process is every bit as relational. A mercury thermometer responds one way, an air thermometer another. As I have shown, Bacon thinks that the analogy to such inanimate acts of perception is a close one, and the analogy shows that relativity is no barrier to the detection or to the awareness of objects and qualities.

⁶³ *N.O.* II. 40. Cf. *Partis instaurationis*, p. 553.

⁶⁴ *N.O.* II. 40.

⁶⁵ *N.O.* II. 13; cf. II. 14.

The particular deceptions must include all of those deceptions which result from something other than the relational nature of sense-perception. An example might be the belief that the slowly diminishing sound made by a vibrating string is one and the same sound across time, when in fact, according to Bacon, the sounding body must continually renew its sound by causing new vibrations in the air.⁶⁶ Hallucinations might be another example. Since both of these examples are mentioned in the *Sylva sylvarum* in the context of an investigation into the senses and their objects, and since that is exactly the context Bacon says is appropriate for discussing particular deceptions, it is reasonable to conclude that this is what they are.

Are hallucinations true? Do they undermine our belief in the truth of ordinary sense-perceptions? Bacon never dwells on hallucinations as if they were some sort of epistemic problem, but consider this passage in the *Sylva sylvarum*:

Drunken men imagine every thing turneth round; they imagine also that things come upon them; they see not well things afar off; those things that they see near hand they see out of their place; and (sometimes) they see things double. The cause of the imagination that things turn round is, for that the spirits themselves turn, being compressed by the vapour of the wine (for any liquid body upon compression turneth, as we see in water); and it is all one to the sight, whether the visual spirits move, or the object moveth, or the medium moveth.⁶⁷

Bacon continues by explaining the causes of the other phenomena associated with drunkenness. Throughout the passage, he demonstrates that these non-veridical cases are to be handled in roughly the same way as veridical cases. There is an objective process at work when compression turns water. When the world spins for a drunk, it is the same objective process, except that in this case the drunk has a special conscious perspective on that process. The drunk, in other words, is registering the turning of his own spirits. Those spirits, it is important to remember, are nothing but matter—they are located inside the drunk's body, but they are still mind-independent. We can say, then, that the drunk is aware of a

⁶⁶*Sylva sylvarum* in Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 2, p. 207.

⁶⁷*Ibid.*: p. 725.

mind-independent object. In this sense, hallucinations are just as true as veridical sense-perceptions.

If my account of Bacon's view is correct, one might wonder why he is so willing to talk in terms of faults of the senses. After all, the atomists would shy away from that kind of language. Shouldn't Bacon, too, deny that these faults exist and attribute any faults entirely to the mind? Perhaps, but his willingness to speak this way can be accounted for. When he calls the senses faulty, he only means to highlight the fact that they could have been better. As Peter Harrison observes, it was not unusual for Bacon's contemporaries to hold that, before the Fall, Adam had superior sense organs, and Bacon may have shared this view.⁶⁸ Our hearing could be keener, our eyesight more penetrating. Perhaps we might even be able to conceive of a kind of sense-perception that would give us direct access to the natures of things.⁶⁹ Instead of feeling heat, we would feel particulate motion; instead of seeing color, we would see the subtle textures and schematisms that give rise to color. Compared to this (perhaps prelapsarian) ideal, the senses are faulty. But these sorts of faults do not threaten the truth of sense-perception.

3.4 What are the Consequences of Withholding Assent to the Reports of Sense-perception?

Thus far, I have argued that Bacon, largely following the atomists, has an account of sense-perception which, if true, would guarantee that the senses always provide us with an awareness of mind-independent things. However, on pain of vicious circularity, we cannot take that account as an argument for the truth or certainty of sense-perception since both Bacon and the atomists defend their accounts of sense-perception by appealing to sense-perceptions. We have to

⁶⁸Harrison, *The Fall of Man and the Foundations of Science*: pp. 174-5.

⁶⁹Bacon says in *The Advancement of Learning* that man before the Fall had "the pure knowledge of nature and of universality, a knowledge by the light whereof man did give names unto other creatures in Paradise, as they were brought before him, according unto their properties." It is not clear whether Bacon credits this prelapsarian knowledge of the natures of things to superior mental faculties, superior sense organs, or to both. Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 3, pp. 264-5.

study drunk people empirically, for example, in order to determine the causes of their hallucinations and thereby to support an account of sense-perception which renders hallucinations innocuous.

That sense-perception is true is something that has to be presupposed, then. After presupposing it, Bacon can go on to offer support for the account developed in this chapter, which fleshes out the exact sense in which sense-perceptions are true and defuses any reasons for doubt offered by the skeptics.

Importantly, though, Bacon does have something more to say in defense of his choice to presuppose the truth of sense-perception from the beginning. Here he draws on arguments from both the atomists and the Stoics, so I will begin with them.

3.4.1 Ancient Views

The family of arguments I have in mind says, roughly, that the skeptical attitude towards sense-perception poses a danger to the way we live our lives and to our ability to know the world and do science. The details of the argument are subject to a good deal of variation depending on whether the particular skeptical attitude targeted for attack is more Pyrrhonian or more Academic, and whether the concern is with the effects on daily conduct, self-preservation, moral conduct, the work of science, etc. For our purposes here, we need only get a flavor of some of the ancient arguments on offer.

One argument which Bacon would have encountered is from Lucretius:

And even if reason fails to resolve the problem of why objects, which close at hand were square, have a round appearance when viewed from a distance, it is better, if one is ignorant of the reason, to give an erroneous explanation of the difference in shape than to let manifest facts slip from ones grasp and to undermine [*violare*] the first principles of belief and tear up [*convellere*] all the foundations upon which our life and safety are based. For if you were not prepared to trust the senses, not only would all reason fall in ruin [*ruat*], but life itself would at once collapse [*concidat*], since you would be unable to avoid precipices and other such dangers and keep to places of safety.⁷⁰

⁷⁰Lucretius, *On the Nature of Things*: 4.500-10.

The target of this argument is any skeptic who claims that we should not trust the senses. It is a little unclear what “trust” means here, and in particular whether some kind of Academic approval which falls short of assent would qualify. David Sedley has argued that Lucretius does not try to reply to any post-Epicurean skeptical philosophers.⁷¹ Let us suppose that Sedley is right. This would leave Pyrrho himself as one of the few possible targets.

Against someone such as Pyrrho, then, Lucretius argues that mistrusting the senses would do harm both to reason and to our lives. The problem for our ability to reason is a result of the the role of sense-perception as the criterion, our ultimate means of deciding whether something is true or false. In reply, Pyrrhonian skeptics might question whether the success of reason should be judged by the construction of a body of science. In their view, the thought that one has some finished body of science is harmful to the pursuit of their desired state of untroubledness—because in fact genuine knowledge is beyond us, and attempting to pursue it results in fruitless and distressing debates.

Another anti-skeptical argument is attributed to the Stoics in the *Academica*:

But if all impressions were the way the Academics say they are, so that they could just as well be false and no examination could discriminate them, how could we say that anyone had proved anything or discovered anything? What confidence could we have in proofs? [...] So it's impossible to doubt our view that none of the wise person's principles can be false—or rather, that it's not enough for them not to be false, but that they must also be secure, fixed, established, and immovable by any argument.⁷²

The argument is that reason requires sense-perception as a criterion, although in this case we need specifically *kataleptic* impressions. The next part of the Stoic argument is that life itself would be toppled by denying this criterion: “So people who deny that anything is apprehensible rob us of the very instruments or tools of life, or rather they completely overturn [*evertunt*] all of life and deprive animals of their minds.”⁷³ In part, this argument builds on the previous argument that

⁷¹Sedley, *Lucretius and the Transformation of Greek Wisdom*.

⁷²Cicero, *On Academic Scepticism*: 2.27.

⁷³Ibid.: 2.31.

reason would be harmed. Since we live by means of reason—using it to develop technology and to discover how to live virtuously—it follows that without *kataleptic* impressions, we would be deprived of our means of life.

An important concern with this whole family of anti-skeptical arguments is that it has no bearing on Academic skepticism, which would allow for us to act on the probable sense-perceptions without regarding them as true. Let us bear that concern as mind as we turn to Bacon’s version of this anti-skeptical argument.

3.4.2 Bacon’s View

Bacon argues that we should affirm the certainty of sense-perception because of the consequences of not doing so. A passage in the *Scala intellectus* is reminiscent of both the atomist and Stoic arguments that reason would be overturned if we sided with the skeptic about sense-perception. After commenting in the *Scala intellectus* on his own affinities to Academic skepticism, he launches into an attack: “by denying the certainty of the senses, [they] pluck up [*evertunt*, i.e., overturn] science from its very foundation [*ab imis fundamentis*, from the deepest foundations].”⁷⁴ The verb *evertunt* is one of the verbs used in the *Academica* by Lucullus in the course of the corresponding argument there, although, to be sure, the verb is common and suitable enough for the context that this could be a coincidence. What is more interesting is whether Bacon’s argument fails to take notice of the Academics’ insistence that we can approve of probable sense-perceptions without granting our assent to them. Bacon, it appears, does take notice of this, mentioning it just a couple of paragraphs prior. Why is the probable insufficient? Because, Bacon says “we, by the introduction of a new method, endeavor to regulate [*regere*] and correct [*restituere*] the aberrations [*errores*] both of the sense and of the intellect,” whereas the Academics do not.

The point seems to be something like the following. Given the limits of our intellect and our senses, scientists are bound to commit some errors early on. Since a probable criterion is one that even erroneous judgments can satisfy, once that criterion is met, there will be no further reason to correct any errors. Furthermore,

⁷⁴*Scala intellectus*, p. 520.

the Academics can offer no method by which to systematically regulate and correct those errors. Science will, as a result, always be vulnerable to error, and we will never arrive at the body of epistemically certain science which Bacon desires. In order to avoid this consequence, sense-perception must be regarded as certain rather than as merely probable.

Now, one might ask why one cannot combine a probable criterion with a method that systemically regulates and corrects errors, and even why one cannot have a method which is the same as Bacon's in every respect except that it substitutes a probable criterion for a certain one. Even if an erroneous judgment initially meets the standard of probability, it is not clear why one should not be able to pursue and be motivated by still greater degrees of probability.

Bacon's argument makes more sense when conjoined with his view that sense-perception is an *alogos* difference-detector. Remember that a single false sense-perception would, for Bacon, require a breakdown of causality. The skeptical attitude towards the senses implies that we are sometimes, as it were, severed from the world. But if we are willing to grant that we are sometimes cut off from the world, is there any justification for thinking that we usually register it more reliably? We might rely on what we take to be the most coherent interpretation of all of our past experience, but I take it that Bacon doubts this can be done methodically, in the absence of an absolutely privileged starting point.

Given the tight relationship in Bacon's view between knowledge and power, we should expect these considerations to have disastrous practical consequences as well. And indeed, Bacon says as much:

For no matter how they want to be seen, through their distinction between the true [*veri*] and the credible [*probabilis*], to destroy the certainty of science [*scientiae certitudinem*] but to retain its usefulness, and, as far as the practical part [*activam partem*] goes, to leave our prized possessions uninjured, nevertheless, having lifted from the souls of men the hope of inquiring into the truth [*veritatis*], and obtaining an indiscriminate license, they have turned the work [*negotium*] of discovery into a sort of exercise of wit and disputation.⁷⁵

⁷⁵Bacon, *The Works of Francis Bacon, Lord Chancellor of England*: Vol. 2, pp. 687-8, my translation.

If Bacon is arguing that the substitution of probability for truth necessarily destroys hope and thus destroys our motivation to enhance human life with new discoveries and inventions, then his argument is not entirely persuasive. Maybe some individuals would be less motivated, but one might enthusiastically embrace the pursuit of the probable as the best human reason has to offer. There is an empirical component to Bacon's argument as well, however. In actual fact, Bacon claims, those influenced by the Academic skeptics tend to turn towards disputation rather than discovery. Perhaps contingent facts about human psychology explain this tendency; Bacon does not elaborate.

On the whole, my view is that these arguments for the postulation of the truth of sense-perception meet with mixed success. They do not demonstrate that sense-perception is true, but on the other hand that does not seem to be their aim. Rather, they aim to show that the kind of epistemically certain and fruitful science we desire is impossible unless we assume that our senses put us into contact with the world and can therefore be used to identify and correct any intellectual errors. And with respect to this aim, Bacon succeeds.

3.5 Conclusion

I have argued in this chapter that Bacon endorses four atomist theses regarding sense-perception:

1. The immediate objects of sense-perception are mind-independent.
2. The reports of sense-perception are *alogos*, or non-notional and non-propositional.
3. All sense-perceptions are true in that they register mind-independent objects or qualities.
4. If we denied (3), science would be undermined.

I cannot emphasize enough that, for Bacon, regarding sense-perception as certain means regarding it as true beyond a reasonable doubt, and because sense-perception is *alogos*, the claim that sense-perception is true beyond a reasonable

doubt means that there is no reason to doubt that sense-perception is a reliable difference-detector. To regard sense-perception as certain does not require denying the fallibility of the senses. As I have discussed in 3.3, the senses do, according to Bacon, desert and deceive us. But it is not reasonable to regard those desertions and deceptions as evidence that the senses ever fail in their difference-detecting ability.

To defend the status of sense-perception as certain, then, Bacon must be able to respond to any empirically supported reasons for thinking that they sometimes fail to register the world. Bacon's atomist explanations of hallucinations and illusions offer a reasonable model of how to accomplish that job. So we have no reason to think that any sense-perceptions are false. But is it *possible* that some of our sense-perceptions are false? That depends on what we mean by "possible." There is no evidence for it, so it is not possible in an evidentiary sense. For the reasons I have discussed, a false sense-perception would require a breach of causality. On the assumption that we live in a causal world, false sense-perceptions are neither naturally nor metaphysically possible. Still, they are conceivable and present no logical contradiction. If we are radically mistaken about the kind of world we live in, then false sense-perceptions are possible.

This sort of freedom from doubt is, in my view, the best that we can ask of our most foundational knowledge. But it is enough. If a practitioner of Bacon's method can succeed in justifying the truths of natural science on the basis of sense-perception, then there will be no reasonable grounds for doubting those truths. By the same token, those truths could not acquire a higher grade of certainty than is present at the level of sense-perception, so the rest of science is also limited to certainty beyond a *reasonable* doubt as the highest attainable standard. But of course, there is also the question of whether any additional doubts enter into the picture as we engage in Bacon's process of interpretation. So let us move beyond sense-perception and see how natural history is supposed to build on this foundation.

Chapter 4

Baconian Natural History and Scientific Progress

I have argued in Chapter 3 that according to Bacon all sense-perceptions are true. Because sense-perception is neither notional nor propositional, ‘truth’ has a distinctive meaning in this context. A sense-perception is true if and only if it causally registers some mind-independent object; a false sense-perception, if there were such a thing, would have to be one where we are presented with a difference or change in spite of the absence of any corresponding difference or change in the world. In other words, as long as there are no breaches in causality, all sense-perceptions are true. As we saw, even the drunk man’s hallucinations causally register motions inside his own body—in every instance where some kind of motion occurs, a particular hallucination results, and if that motion ceases, the hallucination ceases—and that is enough for a hallucination to count as true.

Since natural history builds on the information supplied by sense-perception, this account of the truth of sense-perception should help us to explain the level of certainty that Bacon ascribes to natural history. He establishes that we have no reason to think that any sense-perceptions, not even illusions and hallucinations, are false, and that is all one can ask of a foundation. The question now is whether the contents of natural history can be justified by the contents of sense-perception without any additional reasons for doubting natural history cropping up along the way. If this can be done, then all of our conclusions about the epistemic status of

sense-perception can be carried over.

The non-notional and non-propositional character of sense-perception, though an important part of the argument that sense-perception is true, poses a challenge to those, such as Bacon, who want to say that natural history is justified by sense-perception. If sense-perception provided us with propositional reports, then we could simply read off the facts of natural history from the world. When the senses made their reports—"the fire is hot," "the thermometer rose," "the gold is hard"—we would simply have to write them down. But if sense-perception is non-notional and non-propositional, the process cannot be this simple. That gives rise to the question of how copious natural histories filled with facts—or instances of phenomena, as Bacon calls them—can be justified by sense-perception.

While I won't argue that Bacon has a fully worked out answer to this question, I think he has a few components of such an answer and that those components are part of a sophisticated and plausible picture of how natural history works. The basic picture is a moderate foundationalist one. Foundationalism is a theory of the structure of the justification of our knowledge which holds that all of our knowledge is justified either directly or indirectly by properly basic beliefs, which are justified beliefs whose justification does not depend on other beliefs. Moderate foundationalism is a variety of foundationalism which states that properly basic beliefs are strongly but not conclusively justified at first, but that they can be further supported or undermined by other beliefs. Although foundationalism is a theory of the structure of the justification of our knowledge and does not *by itself* imply a particular method to be used in building up that structure, Bacon's foundationalism dictates his method of discovery in natural history, as we will see. According to my account of his method of natural history, we are to begin with *alogos* sense-perception, which allows us to grasp some initial notions, and those initial notions, together with sense-perception, justify our first predications. The rest of natural history takes off from there in a continually ascending and descending spiral.

One of Bacon's metaphors for the structure of our knowledge (and for the corresponding order of discovery that we should pursue) is that of a gradually

ascending path that winds around a mountain, going successively up and down, taking the investigator a little higher each time. He calls this path both a ladder (*scala*) and a “Thread of the Labyrinth.”¹ One of my claims is that this labyrinthine method can be captured with Figure 4.1, which I will flesh out over the course of the chapter.

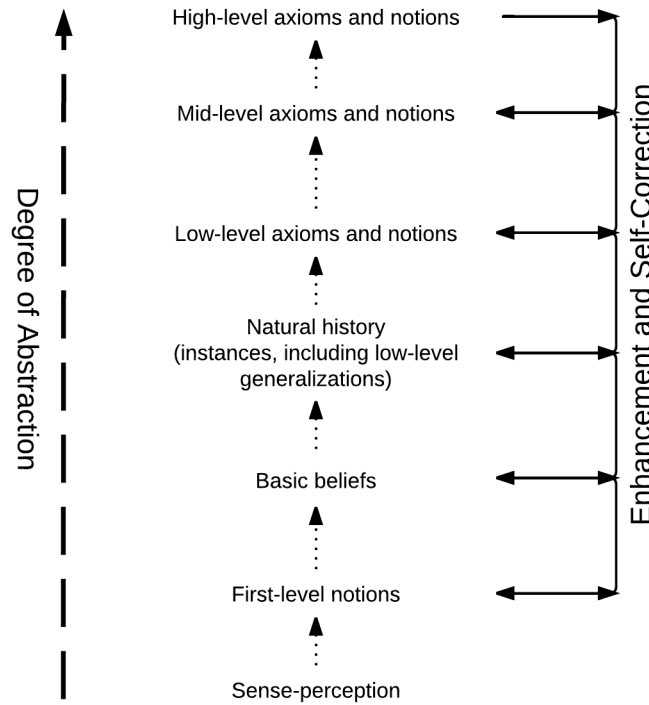


Figure 4.1: The Order of Discovery and the Structure of Justification

A dotted arrow from A to B signifies that A provides the initial justification for B. Only after there is some initial justification for items on a particular level can that level properly be used for the enhancement and self-correction represented at the right.

Another good metaphor for Bacon’s view is a domed cathedral. Some of the cathedral rests underneath the dome and sits securely on the ground. Each part of the dome, on the other hand, can be fully supported only after the dome is complete, so some kind of scaffolding system has to be used. There is a sense in which each piece of the dome is supported by all of the pieces below it, yet those

¹See both the title and contents of the *Scala intellectus*. Bacon continues to use this metaphor in the *Instauratio*. For example, the *Distributio operis* still refers to Part Four as the “*Scala Intellectus*.” Bacon, *The Instauratio magna Part II: Novum organum and Associated Texts*: B2^r 8.

lower stones could not have been locked into place without using the scaffolding to put the higher stones into place. Furthermore, mistakes may be made along the way, and the cathedral can be renovated again and again through the years as defects come to light. Bacon holds that any errors “will be easily expunged and rejected soon after by the causes and axioms” that his method allows to be discovered, as long as the errors are not so widespread that one utterly fails to converge on those causes and axioms.² So one might knock some parts of the cathedral down based on information coming from up above. Despite this continual progress and refinement, at some point one does have a structure that can withstand the test of time.³

Throughout this chapter, my focus will be on how progressively increasing degrees of certainty are supposed to be attained within natural history—that is, within the third part of the *Instauratio*. The certainty of our inductions based on natural history bears on this topic—after all, part of my argument in this chapter will be that Bacon thinks we should cycle back and forth between the different parts of the *Instauratio*—but the specifics of the method of induction are complex and will be treated separately in Chapter 5.

I will proceed as follows: 4.1 will introduce the notion of Baconian natural history and discuss how it is informed by higher-level theorizing while still serving as a foundation for theorizing; 4.2 will explain Bacon’s view that there is no weighty distinction between the context of discovery and the context of justification in order to allow us to draw on Bacon’s ideas about the process of discovery over the

²*N.O.* I. 118.

³John Norton offers an account of the structure of justification that is similar to this one, and the domed cathedral metaphor is his: “the edifice of science is like a stone arch or a stone dome or even an elaborate medieval cathedral, with many smaller arches and vaulted ceilings. Each of the stones gains structural support from stones elsewhere. A stone high in an arch cannot fall because it is supported by stones beneath and in the other column; and the totality is locked into place by a keystone higher in the arch.” Norton also employs the scaffolding metaphor: “How are arches, domes and cathedrals built in the first place? Their stones are supported initially by scaffolding [...] The analog of a stone temporarily supported by scaffolding is the proposition introduced tentatively as an hypothesis or even conjecture.” Norton, “A material dissolution of the problem of induction”: p. 687. One difference between Bacon and Norton is that Bacon thinks that this justificatory scheme can bring us certainty, whereas Norton thinks that it can bring us only “near certainty” by locating the risk of error in assumptions that become less and less questionable over time. For this point, see Norton, “Science and Certainty”.

course of the chapter (which deals more directly with justification than discovery); 4.3 will argue that our foundational knowledge, for Bacon, includes what I will call first-level notions, or notions of *infima species* and of immediate apprehensions of sense-perception; 4.4 will proceed further up in the hierarchy of knowledge and examine how the first iteration of a natural history might be justified; 4.5 will look at the mechanisms Bacon thinks should be employed to revise and correct those natural histories over time; and 4.6 will consider some objections and offer replies.

4.1 What is a Baconian Natural History?

One way of understanding the nature of a Baconian natural history is to look at its place in the *Instauratio*. Recall that the six parts of the *Instauratio* are as follows: (1) a classification of the sciences along with a summary of the status of each science, (2) the *Novum organum*, which states the method of induction, (3) natural history, (4) a part in which the method of induction is applied to natural history and some initial, tentative conclusions are reached (which might be called speculations if they are weakly supported or First Vintages if they are well-supported), (5) still more radically speculative theories (called anticipations of nature) reached without the aid of induction, and (6) the results of finished inductions. This structure—in which Part Four involves the application of Part Two to Part Three—reflects Bacon’s claim in the *Parasceve* that natural history contains “the basic stuff and raw material of true induction.”⁴ What is a Baconian natural history, then? One answer is that it is a set of particular instances about a subject of investigation, used as the data for induction.

This conception of Baconian natural history has led Bacon to be portrayed as a simple-minded empiricist foundationalist who believed that facts could be derived directly from sense-perception and then immediately used for the data of induction. As this portrait of Bacon’s method would have it, fact-gathering and theorizing are two separate and distinct stages of Baconian science; the method of induction is to be applied to the facts, and out will come the knowledge of formal

⁴Bacon, *The Instauratio magna Part II: Novum organum and Associated Texts: Parasceve* 2.

causes. Part of my argument in this chapter is that this portrayal of Bacon is a myth and a caricature, but it is certainly a persistent one. Ian Stewart (who agrees that it is a myth) finds traces of it even in Bacon's early readers:

Just as historical accounts of Bacon have tended to misrepresent his notion of inductive logic as a theoretically-uninformed processing of empirical data, even more so has he been misunderstood with regard to the character of his natural histories; i.e., the empirical ground of such inductions and their intimate relation to whatever noetic activity induction is thought to constitute. Above all, this part of Bacon's Instauration has been identified with a kind of 'theory-free' aspect of his thought. This was true in his earliest continental readers like Mersenne and Gassendi [...]⁵

This myth about Bacon was so widespread just a few decades ago that it constituted part of what Peter Urbach termed "The Standard Interpretation," according to which natural history "must betray no theoretical presuppositions at all, and should consist of 'pure' facts, infallibly drawn from 'direct' observation."⁶ Karl Popper offers the same interpretation, referring to Bacon's "myth of a scientific method that starts from observation and experiment and then proceeds to theories."⁷

Some commentators have recently begun to recognize that this reading of Bacon cannot be the full truth. To Dana Jalobeanu, for example, it neglects the role of Bacon's speculative theories in his Latin natural histories. She suggests instead that natural history, for Bacon, has two different meanings depending on where we look. On the one hand, we can turn to the works Bacon wrote to introduce his natural histories, where he discusses the method of natural history abstractly. She claims that these works, including the *Parasceve*, describe natural histories as vast storehouses of facts that serve as the foundation for induction.⁸ On the other hand, there are Bacon's actual attempts at natural history, including

⁵Stewart, "*Res, veluti per Machinas, Conficiatur*: Natural History and the 'Mechanical' Reform of Natural Philosophy": p. 109.

⁶Urbach, *Francis Bacon's Philosophy of Science: An Account and a Reappraisal*: p. 20.

⁷Popper, *The Logic of Scientific Discovery*: p. 279.

⁸For further discussion of the idea of a Baconian natural history as a storehouse containing material for induction, see Giglioni, "*Historia and Materia*: The Philosophical Implications of Francis Bacon's Natural History".

the *Historia ventorum*, *Historia vitae et mortis*, as well as the *Sylva sylvarum*, all of which present natural history not as a set of facts but as a diachronic process of observation and experimentation structured by theoretical presuppositions.⁹ As Jalobeanu correctly identifies, the natural histories include not just facts but also “the description of experimental procedures, advice and counsels, suggestions for further experimentation, provisional explanations of causes or theoretical assumptions, words of ‘caution’ and ‘advice,’ questions, etc.”¹⁰ With the exception of provisional explanations and suggestions for further experimentation, the *Parasceve* does prescribe these elements (in fact, it even prescribes recording received opinions), but Jalobeanu’s larger point, that the *Parasceve* treats natural history as a more or less finished body of factual information about instances, is right. And she suggests on this basis that Bacon is ambivalent about whether a natural history is a set of facts or a process of inquiry—and ambivalent, therefore, about the role of theories in the construction of natural history. On the one hand, he wants to be guided by theoretical presuppositions in the process of doing natural history; on the other, he wants to emerge in the end with a set of cut-and-dried, theory-independent facts.¹¹

In thinking about this puzzle, and to assist in describing the nature of a

⁹Bacon’s intermingling of natural philosophy with natural history is also a theme which Peter Anstey has discussed. He demonstrates areas of overlap between the two within Bacon’s scheme for classifying the sciences. See Anstey, “Francis Bacon and the Classification of Natural History”: pp. 11-31.

¹⁰Jalobeanu, “Core Experiments, Natural Histories and the Art of Experientia Literata: The Meaning of Baconian Experimentation”: p. 90. Jalobeanu says in passing that it is the “final product” which includes these features, whereas it will be an important part of my interpretation that the final product should *remove* some of these features. At the very least, those that are not mentioned in the *Parasceve*, provisional explanations and suggestions for further experimentation, should be removed. It will soon be clear why Bacon omits these from the *Parasceve*, since (as I will argue) that work describes natural history at a finished stage where there would be no need for these things.

¹¹Elsewhere, Jalobeanu has adopted the helpful distinction between theory-informed natural history and theory-driven natural history. Jalobeanu finds examples of Bacon using theories to inform his natural historical work, but she does not claim to find evidence of Bacon being driven by his theories or of his being motivated by a desire to confirm his preconceived notions. I agree with Jalobeanu that Baconian natural history is theory-informed without being theory-driven. What I will want to emphasize is that this information is coming from a higher level in a justificatory structure and that this top-down mechanism is related to Bacon’s quest for certainty. Jalobeanu, “Learning from Experiment: Classification, Concept-Formation, and Modeling in Francis Bacon’s Experimental Philosophy”.

Baconian natural history more accurately, I suggest we turn to a little-studied 1625 letter from Bacon to Father Fulgentio. Commenting on his Latin natural histories, Bacon states:

As for the third part, namely, the ‘Natural History,’ that is plainly a work for a King or Pope, or some college or order: and cannot be done as it should be by a private man’s industry. And those portions which I have published, concerning ‘Winds,’ and concerning ‘Life and Death,’ are not history pure: because of the axioms and greater observations that are interposed: but a kind of writing mixed of natural history and a rude and imperfect intellectual machinery; which is the fourth part of the ‘Instauration.’¹²

This passage raises two questions. First, what does Bacon mean by pure natural history, and how does it differ from impure natural history? Second, Bacon suggests that his decision to publish impure natural histories is a result of the fact that proper natural histories are impossible for one person working alone. But why? Is Bacon saying that pure natural histories were beyond his capacity?

We first need to determine what Bacon means by “history pure.” The passage says that Bacon’s natural histories are impure “because of the axioms and greater observations that are interposed.” So purity is a matter of the absence of material that does not belong to Part Three of the *Instauratio*. Since speculations about causes belong to Part Four of the *Instauratio*, the inclusion of those speculations renders the history impure.

But now if we turn to the second question, we have a problem. If a pure natural history is just one which lacks everything but the natural historical instances, then it is easy to write a pure natural history. Simply refrain from discussing causes and axioms. It is true that Bacon says that an *ideal* (as against pure) natural history would require a vast, collaborative effort, but there he seems to have in mind the difficulty of generating a complete, reliable, and certain natural history,

¹²Bacon, *The Letters and the Life of Francis Bacon*: Vol. 7, p. 553, n.2. See also Bacon’s preface to the *Parasceve*, where he emphasizes that natural history is too demanding an undertaking to be completed by one person working alone. Bacon, *The Instauration magna Part II: Novum organum and Associated Texts*: p. 451. The difficulty of natural history is then offered in the third aphorism of that work as a justification for sticking to the facts and keeping natural history concise.

rather than the difficulty of generating a pure natural history. These are two different things. An incomplete and uncertain natural history could easily refrain from discussing causes and axioms, so why does the impossibility of an ideally complete and certain natural history lead Bacon to intertwine material from Part Four with the natural histories of Part Three? One might also ask the corresponding question: if an ideally complete and certain natural history *were* produced, should one at that time remove from it any discussions of causes and axioms? If so, why? What advantage might be gained by such an act of omission?

The contrast between pure and impure natural history corresponds to a contrast between the *Parasceve* (which was appended to the *Novum organum*) and the *Historia naturalis et experimentalis* (which introduced a volume of the same name containing the *Historia ventorum*). Although the *Parasceve* does not prescribe a completely exhaustive or absolutely certain natural history, one important way in which it differs from the *Historia naturalis* is in the fact that it does not call for discussions of causes within the natural historical text. It lists only five additional, non-historical features that are to be included—questions, descriptions of how an experiment was performed, admissions of any doubts, observations about patterns, and reviews of received opinions. Although Bacon calls for questions to be added, he stresses that these are to be questions about the facts, not questions about causes (“*non Causarum dico, sed Facti*”), and the observations pertain to pattern-recognition and stop short of speculating about the causes of these patterns. Furthermore, Bacon stresses that natural history should be as brief as possible and omit superfluous elements.¹³ For these reasons, I read the *Parasceve* as describing pure natural history. The *Historia naturalis*, on the other hand, says that the natural histories which Bacon now (*nunc*) attempts—the word ‘*nunc*’ does not need to be there unless Bacon means to indicate a contrast with the *Parasceve*’s method—will include speculations (*commentationes*) and “imperfect attempts (*rudimenta*) at the interpretation of causes.”¹⁴ Bacon even refers to his

¹³“For in this great work it is just as important to write down succinctly what is adopted as it is to cut away what is superfluous, though no doubt this kind of chastity and brevity will provide much less amusement both to the reader and to the writer.” Ibid.: *Parasceve* 3.

¹⁴Bacon, *The Instauration magna: Part III: Historia naturalis*: C5^v 1.

Historia ventorum as a “history in embryo” (*historia designata*),¹⁵ in stark contrast to the “Mother History” described in the *Parasceve*, since it has not yet grown into a body of relatively complete and certain information that includes “material tested [*probam*], abundant [*copiosam*] and properly arranged for the work of interpretation which will follow it.”¹⁶ So the *Historia naturalis*, but not the *Parasceve*, describes impure natural histories such as the ones Bacon himself attempted and published.

I can think of two explanations for why Bacon might see a connection between the point about collaboration (and the present impossibility of complete and certain natural histories) and the point about purity:

The Rhetorical or Motivational Explanation: An important aim of Bacon’s Latin natural histories is to motivate others to join his effort and ultimately establish the necessary collaborative enterprise. For example, he displays an interest in the *Historia naturalis* in the great intellects “scattered the length and breadth of Europe” and worries that a possible disciple might “give up what he already has before he has taken possession of something better.”¹⁷ *Prodromi philosophiae secundae*, although it primarily concerns Part Five of the *Instauratio*, displays the same concern with motivation: “But for those who, following my guidelines, shall resort to the true interpretation of nature and work to bring it about, these same things [i.e. anticipations about causes] can act as resting places or wayside inns made available to give them comfort and good cheer, and meantime to help human fortunes to some degree and flood minds with thoughts which have a rather closer kinship with nature.”¹⁸ Bacon seems to believe that discussions of causes and axioms, if they are interspersed with otherwise dry histories, will help his readers see the value of his natural historical project and inspire them to make their own contributions.

The Epistemic Explanation: This explanation alleges that the knowledge of the instances in a complete and certain natural history is epistemically dependent

¹⁵Bacon, *The Instauratio magna: Part III: Historia naturalis*: C4^r 20.

¹⁶Bacon, *The Instauratio magna Part II: Novum organum and Associated Texts*: pp. 453, 451.

¹⁷Bacon, *The Instauratio magna: Part III: Historia naturalis*: B6^v 24, B8^r 1.

¹⁸Bacon, *The Instauratio magna: Last Writings*: R2^v.

on the knowledge of causes and axioms. Therefore, one cannot make the necessary progress on Part Three without jumping ahead to Part Four and continually shuffling between the two parts and making incremental improvements to each of them on each subsequent iteration. According to this explanation, impure natural histories are to be used as stepping stones to a more complete and more certain natural history. Importantly, collaboration would not mitigate the need for impure natural histories, on this account, although it would accelerate their development.

Note that these explanations can be combined. Bacon may see both motivational and epistemic value in the dissemination of impure natural histories.¹⁹ My focus here is obviously epistemic, but I do not mean to discount the importance of other explanations of Bacon's choice to write impure histories. My view is that when Bacon uses higher-level notions and axioms to guide his natural historical work, he thinks that he has a method that ensures that those guiding notions and axioms will either be true or be continually revised or replaced until they are true. Then, when the goal of a relatively complete and certain natural history is reached, the interwoven non-historical material should be removed, perhaps because of the desirability of brevity mentioned in the *Parasceve*, or perhaps to assist in a division of labor between historians and interpreters of nature à la *New Atlantis*.

So what is a natural history, for Bacon? It is a set of well-justified factual information about a phenomenon in nature. But *how* it is to be justified is another story, which is where the non-historical devices in the impure natural histories enter the picture. Ultimately, this chapter aims to present a fuller account of that process.

¹⁹It is probably also true that, in some respects, Bacon's thinking about the purity of natural history evolved over time. I take my account of Bacon's method to apply principally to his mature work. Comparing and contrasting Bacon's *Phaenomena universi* (dated by Rees to about 1611) with the later *Historia densi et rari*, one can see that Bacon decided to add four headings absent from the earlier work: speculation (*commentatio*), connection (*connexio*), provisional rules (*canones mobiles*), and desiderata. These four newly added types of sections all emphasize relationships between the natural history and Part Four of the *Instauratio*.

4.2 The Unity of Discovery and Justification

But first we have to deal with the lack of textual evidence pertaining to Bacon's views about justification. It is widely acknowledged that Bacon is more concerned with discovering new knowledge than with justifying what we do know (although given the considerations in Chapter 2, he clearly does display some concern for justification). As a result, there are many more places where Bacon offers advice about discovery than there are places where he talks about reconstructing a justification.

In this section, I will circumvent this problem by arguing that Bacon accepts the following four theses about discovery and justification, which serve to unify them:

- B-1 The act of discovering any notion, fact, or axiom (or anything truth-evaluable) justifies the acceptance of that item.
- B-2 Justification is the tracing of a possible path of discovery.²⁰
- B-3 The very same method ought to govern both discovery and justification.
- B-4 At least in some cases, the best justification (if more than one justification is possible) is the one that traces an actual historical path of discovery.

My concern in this section is just to show that Bacon accepts these theses, not to defend them, in order that I can then use passages from Bacon about the proper method of discovery to infer his view about the structure of justification, and vice versa.

4.2.1 The Scholastics' Discovery-Justification Distinction

The distinction between the context of discovery and the context of justification is usually traced back to Reichenbach's 1938 book *Experience and Prediction*, despite the fact that conceptions of the distinction have evolved significantly since

²⁰For a recent defense of this thesis, see Nickles, "Positive Science and Discoverability": p. 19; and Nickles, "Truth or Consequences? Generative Versus Consequential Justification in Science".

then and existed in different terms beforehand. Bacon, of course, would not have been aware of this contemporary issue. But he was aware of a similar Scholastic distinction, and it is worth looking at his critique of it.

The Scholastic version of the distinction holds that discovery and justification are distinct in at least the following ways, corresponding to the four theses that I will attribute to Bacon:

- A-1 One typically discovers that P is true (and comes to have non-scientific knowledge of P) before later justifying P, i.e., before explaining why it is necessarily true. Thus, the same mental act which discovers P does not immediately justify P.
- A-2 Justification cannot trace a possible path of discovery. The path of discovery must begin with sense-perception (or with what is better known to us), whereas a justification must begin with first principles (or with what is better known to nature).
- A-3 The method which governs justification cannot also govern discovery.
- A-4 The best justification does not follow the actual historical path of discovery (based on A-2).

Anyone who has studied Euclid's *Elements* or any other ancient mathematical text has probably contemplated the Scholastic version of the distinction, perhaps without realizing it. We all notice that even though the justification of the Pythagorean Theorem is rather lengthy and begins ultimately with definitions and axioms, the discovery of the theorem must have been originally made in some other manner. The proof that Euclid provides, readers have long assumed, is the result of his working backwards from the already discovered theorem.

This observation is what famously led Descartes to declare that the ancient mathematicians concealed their method of discovery "like a sacred mystery."²¹ Synthesis, for Descartes, named the method of proof that proceeded from first

²¹ "Second Set of Replies," in Descartes, *The Philosophical Works of Descartes*: Vol. 2, pp. 110-11.

principles to the desired conclusion; analysis, when contrasted with synthesis,²² named the process of working backwards from what is treated as if it is already known to the principles on which that item depends. Analysis, he believed, was the esoteric method of discovery of the ancients, whereas synthesis was the exoteric mask that they put on when disseminating their ideas. Although analysis could be used as a method of demonstration as well, Descartes believed that it produced demonstrations that more closely followed the path of discovery. For example, he claimed that the *Meditations* followed the analytic method since it comes upon the rule that whatever one clearly and distinctly perceives is true by working backwards from putative items of knowledge.

This distinction between the analytic and synthetic methods is evidence that something like a discovery-justification was in the air around Bacon's time. One source of the distinction, as Descartes suggests, was ancient mathematical texts and the many commentaries on them. But another source of the distinction, one which (as we will see) Bacon has in mind, is Aristotle.

There are three pieces of Aristotelian doctrine which jointly give rise to the weighty discovery-justification distinction encapsulated by A-1 to A-4. The first piece is the view that *episteme* or scientific knowledge of a proposition comes as the result of syllogistic reasoning. This view already stacks the deck in favor of the distinction. For although proof is thought by the Aristotelian to be syllogistic, it would be hard to defend the view that principles can be *discovered* just by following the rules of syllogistic logic.

The second important piece of Aristotelian doctrine is the view that *episteme* of a proposition requires an understanding of the cause or of the reason why that proposition is true. In the context of a syllogism, this means that the middle term in the syllogism must be causally explanatory of the conclusion in order for the syllogism to be demonstrative. Here is an example of a syllogism which meets that condition:

(4.1)

²²This is sometimes called the regressive conception of analysis. Descartes also sometimes uses the concept of *analysis* in a more decompositional sense relating to the activity of taking apart wholes.

- (1) All dogs are carnivores.
- (2) All carnivores have incisors.

∴ (3) All dogs have incisors.

Why do dogs have incisors? Because they are carnivores. They have incisors because they need them to eat meat. A dog's being a meat-eater explains its possession of incisors. The view that the middle term must be causally explanatory is important because causes are generally known to us after we already know (in an unscientific way) their effects. Oftentimes we directly observe the effects and infer the causes from them.

The final piece of Aristotelian doctrine is the view that knowledge proceeds from what is clearer to us to what is clearer by nature (where what is clearer by nature, I take it, is what is causally fundamental). The process of discovery must proceed from what is closest to sense perception on up to the fundamental principles.

Taken together, these three pieces of Aristotelian doctrine imply that the paths of discovery and proof proceed in opposite directions. The path of discovery must start with sense-perception and proceed on up to more and more general principles, but syllogistic demonstrations must reverse the order and show how the general principles necessitate the propositions that are closer to sense-perception. (This is not to say that one cannot alternate between the two paths and use progress in one to fuel progress in the other.) Accordingly, we can note in the above example that one discovers that all dogs have incisors before discovering that all carnivores have incisors, even though the order of the proof or demonstration, i.e., the order of justification, goes in the other direction.

Bacon himself makes this point concisely in the *De augmentis*. In Aristotelian logic, he says, “the discovery of the middle term is one thing, and the judgment of the implication is another; for the mind ranges first, and rests afterwards.”²³ “Ranging” is probably a reference to noetic insight or to the mental consideration that, for *regressus* theorists, transforms confused or unscientific

²³*De augmentis*, Vol. 4, p. 428.

knowledge of an effect into clear and distinct knowledge.²⁴ In a passage that describes the dominant mode of discovery, he puts a more sarcastic spin on what this use of noetic insight or *meditatio* really amounts to: “Now this manner has nothing more to it than that when a man gets ready and girds himself up to discover something, he first searches out and reads over what others have said on the matter; then he brings his own thinking [*meditationem*] to bear and, with much agitation of mind, excites and as it were invokes his own spirit to deliver its oracles to him.”²⁵

I take it that this is a description of the mode of discovery that the *regressus* method leads to in practice rather than a faithful and charitable account of the explicit doctrine, but it still helps reinforce the point that Scholastics are implicitly committed to A-1 to A-4. After all, the best explanation of such a *de facto* methodology is that their theoretical commitments leave them no better alternative. Their doctrine tells them what would make for a good demonstration, but not how to find the demonstrations when they do not yet exist. And therefore they invariably regurgitate the views that they absorbed from their reading.

I grant that this is all very abstract. Particular manifestations of the discovery-justification distinction may differ from Aristotelian to Aristotelian. It is also important to clarify that I am claiming only that those who accept these three standard items of Aristotelian doctrine are *implicitly* committed to A-1 to A-4. They may have no explicit views on the discovery-justification distinction, or their views may even run counter to A-1 to A-4.

4.2.2 Evidence that Bacon Rejects the Distinction

My attribution to Bacon of B-1, B-2, and B-3 rests primarily on the same passage from the *De augmentis* which made the point that the syllogistic method

²⁴Nicholas Jardine provides a useful summary of the usual steps of a regressus: “(1) By observation we obtain accidental or ‘confused’ knowledge of an effect. (2) By induction combined with demonstration of the fact we obtain accidental knowledge of its cause. (3) Through a noetic process of *negotatio* (*meditatio*, *consideratio*) we obtain absolute or distinct knowledge of the proximate cause, grasping the necessity of the link between it and its effect. (4) By demonstration of the reasoned fact we obtain absolute knowledge of the effect, knowledge of it through the cause which necessitates it.” Jardine, “Epistemology of the Sciences”: p. 687.

²⁵*N.O.* I. 82, L2^v 33.

does imply a weighty discovery-justification distinction. The full passage introduces the art of judgment and makes the point that one does not need a separate discussion of the art of judgment by induction since the art of discovery by induction (the method of the interpretation of nature which is treated in the *Novum organum*) already accomplishes everything the art of judgment aims at:

Let us now pass on to Judgment, or the art of judging, which handles the nature of proofs and demonstrations. In this art (as indeed it is commonly received) the conclusion is made either by induction or by syllogism [...] With regard however to judgment by induction there is nothing to detain us; for here the same action of the mind which discovers the thing in question judges it; and the operation is not performed by help of any middle term, but directly, almost in the same manner as by the sense. For the sense in its primary objects at once apprehends the appearance of the object, and consents to the truth thereof. In the syllogism it is otherwise; for there the proof is not immediate, but by mean. And therefore the invention of the mean is one thing, and the judgment of the consequence is another; for the mind ranges first, and rests afterwards.²⁶

Bacon says nothing more about the art of judgment by induction beyond this. The impression one gets from the passage is that everything Bacon has to say about the art of judgment by induction is implicit in his account of a method of discovery in the *Novum organum*.

But judgment is not a synonym for justification, so why do I think that this passage implies a view on the Scholastic's discovery-justification distinction? Well, we need to think more carefully about what judgment means in this passage. Standard logic textbooks in the early sixteenth century in England draw on Aristotle and Ramus to support a division of logic or dialectic (which are typically identified with each other) into two parts, invention or discovery, and judgment or disposition.²⁷ Invention finds the arguments, and disposition assembles them in such a way that a judgment can be made. Ramus himself draws on Rudolph Agricola, who divides dialectic into "the part consisting in thinking out the middle term or argument" (*pars inveniendi*) and the part "by which we judge similitude."

²⁶*De augmentis*, Vol. 4, p. 428.

²⁷See for example the 1628 textbook by Spencer, *The Art of Logic*: Ch. 2.

The role of similitude in judgment is made clearer by Walter Ong's observation that both Ramus and Agricola conceive of judgment in visual terms, such that the sequence of propositions that is assembled by judgment is analogized to a set of cloths that are matched together by juxtaposing them end to end.²⁸ A similar analogy might compare invention to the creation of the pieces making up a LEGO tower and judgment to the assembly of the tower and the confirmation that it is structurally sound.

But Bacon does not entirely accept these received divisions. He divides logic into four parts, the art of invention, the art of judgment, the art of retaining, and the art of transmitting, thereby broadening logic to include what Ramus had considered the domain of the distinct art of rhetoric:

The logical arts are four in number; divided according to the ends at which they aim. For men's labor in rational knowledges is either to invent that which is sought, or to judge that which is invented, or to retain that which is judged, or to deliver over that which is retained. So therefore the Rational Arts must be four; Art of Inquiry or Invention; Art of Examination or Judgment; Art of Custody or Memory; and art of Elocution or Tradition.²⁹

It is significant that Bacon chooses not to use Ramus's preferred term for the art of judgment, disposition. The choice not to use the visual metaphor embedded in that word seems to reflect Bacon's view that judgment involves rationally examining the argument like a judge, not (as for Ramus) the assembly of what has been found. When Bacon does use the term "disposition," it is for one of the functions of his art of transmission. The arrangement of what has already been discovered is, in Bacon's view, a task for rhetoric, not logic.

Another departure from the received divisions, important in determining the significance of Bacon's invention-judgment distinction, is his division of the art of discovery into two kinds, the art of discovery of speech and arguments on the one hand and the art of discovery of sciences and arts on the other. The received logic, he says, deals only with the former, but his focus is on the latter, and indeed

²⁸Ong, *Ramus, Method, and the Decay of Dialogue: From the Art of Discourse to the Art of Reason*: p. 184.

²⁹*De augmentis*, Vol. 4, p. 407.

he denies that the art of discovering arguments is an art of discovery at all. It is instead a tool for calling to mind what is already known.

Now let us look again at the *De augmentis* passage to see how B-1, B-2, and B-3 are implied by it.

B-1 The act of discovering P by induction immediately justifies P. As

Bacon says, in induction “the same action of the mind which discovers the thing in question judges it.” Here “the thing in question” must be the conclusion of an induction such as a notion or an axiom, rather than arts. My reading might be resisted by claiming that the passage implies only that the act of discovering P is an act in which one *thinks* P is justified, not necessarily an act by which P actually is justified. That is indeed closer to the literal meaning of the words, but it misses the point of the passage, which is to introduce the topic of “proofs and demonstrations.” The point must be that discovering P and proving P are the same action. Otherwise the art of judgment by induction could not be so quickly dispensed with.

B-2 Justification (in the inductive method) is the tracing of a possible path of discovery. On a certain reading of Bacon’s claim that “the same

action of the mind which discovers the thing in question judges it,” B-2 is implied. The question is whether to read Bacon as claiming the conditional, “If an action is one of discovery, then it is one of judgment,” or the biconditional, “If and only if an action is one of discovery is it one of judgment.” A couple of considerations support the latter reading. First, if Bacon denied the biconditional and affirmed only the conditional, then one would expect that there is at least some content to the art of judgment by induction that is not covered by the art of discovery by induction. But Bacon seems to think that there really is nothing more to say. And second, Bacon’s simile to sense-perception suggests the biconditional: “For the sense in its primary objects at once apprehends the appearance of the object, and consents to the truth thereof.” The unity of apprehension and consent (and the lack of anything in the middle) is compared to the unity of discovery and judgment. Sense-perception, in a single action, both registers an appearance and presents it

as veridical. Here there is a biconditional: whenever sense-perception registers an appearance, it presents it as veridical; and whenever it presents an appearance as veridical, it must also be registering an appearance. The registering of the appearance and the presentation of it as veridical are one and the same action. Thus, if the simile is a good one, then whenever there is an act of justification, there is some corresponding act of discovery.

B-3 The very same method ought to govern both discovery and justification . This is not so much stated in the passage as implied by Bacon's purpose in the passage. One purpose of the passage is to explain that no separate art of judgment by induction is necessary once the art of discovery by induction has been supplied. In other words, the interpretation of nature is the proper method for both.

We can find additional confirmation that Bacon believes B-3 by considering what he says about demonstrations in the *Novum organum*:

Thus the order of demonstration [of the Scholastics] is also quite turned upside down. For up to now the practice has been to fly up immediately from the sense and particulars to the highest generalizations, as if to fixed poles about which disputations may turn, and from these to derive the rest by intermediate propositions [...] But my way is to educe axioms successively and step by step, and not to reach the most general ones until last.³⁰

When it comes to demonstrations or justification, as Bacon notes here, the Scholastics begin with principles. By reversing the order of demonstrations and beginning with sense-perception, Bacon brings the order of demonstration back in line with the order of discovery.

There is still a question about how to understand B-1 and B-2. When Bacon talks about induction, does he mean to include *any* method that is inductive, even those (such as induction by simple enumeration) which he rejects? Does the unity of discovery and justification hold only of Baconian induction or of all methods of induction? (These questions don't arise for B-3, which is about the *proper* method

³⁰*Distributio operis*, B4^r.

of discovery and justification, the one we *ought* to follow, because we already know that induction by simple enumeration is not, for Bacon, the proper method of either discovery or justification. Only Bacon's method is.)

Bacon does mention induction by simple enumeration just after the *De augmentis* passage (calling it the "vicious form"), but he says only that he rejects it. He also discusses it at a little more length in an earlier chapter of the *De augmentis* that discusses the art of discovery.³¹ But that passage just explains at more length why he regards it as vicious. Does that help us?

I think it does. If B-1 applies, then the act of discovering P by induction by simple enumeration immediately justifies P. Does Bacon believe that induction by simple enumeration provides justification? At best, only to a small degree or in rare cases. He certainly wouldn't claim universally that it provides justification. For similar reasons, B-2 doesn't apply either. The *purported* justifications of induction by simple enumeration might follow possible paths of discovery, but they are usually *merely* purported justifications which are in fact unsuccessful. That modification of B-2 would make it significantly less interesting philosophically. What is interesting about Bacon's view is that he thinks his own method of discovery by induction can provide successful justifications as a matter of course and successfully double as a method of justification as a matter of course.

Now turn to thesis B-4. So far, it seems that Baconian justification involves tracing the original path of discovery. But I think it would be foolish to deny that alternative justifications can be provided. Today, a photograph of the Earth from space can justify the belief that the Earth is round, whereas the initial discovery of this fact was based on other evidence. This new, modern justification is still the tracing of *someone's* path of discovery. It is the path by which a young student today makes the discovery. But it is certainly not the original path. However, there may often be good reasons for preferring the original path of discovery as one's justification. Not because it is a more certain justification, but because it is a more useful justification. Bacon distinguishes in the *De augmentis* between two ways of transmitting knowledge, the "magistral" and the "initiative." The magistral

³¹*De augmentis*, Vol. 4, p. 410.

method is a dogmatic method where the focus is on teaching the conclusions in such a way that they will be believed, whereas the initiative method retraces the path of discovery so that the whole train of argument can be properly understood and examined, thereby initiating the student, as it were, into the circle of scientists that possesses that knowledge. Bacon says the following about this initiative method:

But knowledge that is delivered to others as a thread to be spun on ought to be insinuated (if it were possible) in the same method wherein it was originally invented. And this indeed is possible in knowledge gained by induction; but in this same anticipated and premature knowledge (which is in use) a man cannot easily say how he came to the knowledge which he has obtained. Yet certainly it is possible for a man in a greater or less degree to revisit his own knowledge, and trace over again the footsteps both of his cognition and consent; and by that means to transplant it into another mind just as it grew in his own.³²

He seems to be saying that the best way to transmit knowledge is to trace for the student the original path of discovery. Why? I believe what Bacon has in mind is the passing down of a research program from one generation to the very next generation. The latter generation needs to pick up where the previous one left off, and for this purpose a justification that follows the path of discovery of the previous generation is the most useful. But this does not imply the absurdity that we should employ difficult geometrical arguments to prove to grade schoolers how big the earth is, because we are not initiating students into the research program that existed in the ancient world. When we *are* training the next generation of researchers in an existing research program, then it is best to take them through the original path of discovery.

4.3 First-Level Notions

Now that we can draw on a more diverse set of textual evidence in order to explore Bacon's views about justification, it is time to return to the main thread of the chapter. Bacon is clear that the structure of justification and the order of scientific inquiry must begin with certain very basic notions that are abstracted

³²*De augmentis*, Vol. 4, p. 449.

directly from sense-perception. Recall from Chapter 2 that a notion, for Bacon, is an abstract idea. The first thing to note about notions is that they are, in Bacon's view, subject to justification (or judgment). Notions, just as much as beliefs, can be well-supported or poorly supported,³³ well-formed or poorly formed,³⁴ firm or shaky, sound or unsound.³⁵ Notion-formation, in short, is subject to epistemic norms. When we follow those norms, we end up with firm, well-abstracted notions; when we go wrong, we end up with shaky, poorly abstracted notions.

I readily admit that it is unusual today to talk about notions as being subject to justification. If it is taken to be a definitional feature of justification that it pertains only to beliefs, I won't quibble over terminology. It is possible that Bacon's term "judgment" is more flexible in this regard than our term "justification." The important point is that there is a method that one ought to use in forming notions, and the failure to use that method, according to Bacon, results in poorly founded (unsound, shaky, unjustified) notions.

It is reasonable to wonder whether this view would have the (seemingly unfortunate) consequence that we somehow go astray just by trying to understand someone else who is using unjustified notions. If Aristotle has a poorly formed notion of "moist," do we go wrong when we try to understand him? Here, on Bacon's behalf, I would suggest a distinction between the entertainment of a notion and the formation of a notion, just as we can distinguish between the entertainment of a belief and the formation of a belief. The entertainment of a notion

³³ "[I]t is necessary to go back to particular instances and their sequencing and order, as I shall point out soon when I come to the manner [*modum*] and means [*rationem*] of setting up [*constituendi*, i.e., of establishing or of erecting] notions and axioms" (*N.O.* I. 59). Here Bacon is referring to the second part of the *Novum organum*. His own method of induction is the right way to establish our notions. Similarly: "This induction must moreover be used not only to discover axioms but also to fix [i.e., draw distinct boundaries around] our notions" (*N.O.* I. 105). I take it that Bacon's method of induction doubles as a method for abstracting notions because, as a method of definition, his method of induction helps to discover, justify, and revise the notions being defined. First-level notions must be abstracted without any explicit appeal to induction.

³⁴ "The syllogism is made up of propositions, propositions of words, and words are markers of notions. Thus if the notions themselves (and this is the heart of the matter) are confused, and recklessly abstracted from things, nothing built on them is sound" (*N.O.* I. 14). Later Bacon uses the notion of "moist" as an example of a notion that "has been rashly abstracted without any due [*debita*] verification" (*N.O.* I. 60). This is Bacon's closest brush with the understanding of justification that takes it to involve the fulfillment of epistemic obligations.

³⁵ "In notions [i.e., those of the scholastics] nothing is sound..." *N.O.* I. 15.

does not obviously require epistemic justification. To form a notion, on the other hand, might involve something like an act or the institutionalization of a policy of integrating, subsuming, or bringing together particulars and regarding them as of-a-kind. That mental act or policy of integration—which is not itself a belief, at least not if having a belief implies having a propositional attitude—is what can be shaky or firm, founded or unfounded.³⁶

Now, poorly justified notions breed poorly justified beliefs. Indeed, any belief that employs a poorly abstracted notion is, in virtue of that fact, poorly justified. Bacon's example is the Aristotelian notion of "moist," one of Aristotle's elementary qualities which, when coupled with the quality of either hot or cold, explains the element of either air or water respectively.

For it signifies what easily spreads round another body; what in itself lacks firm boundaries and cannot stay stable; what easily gives way everywhere; what easily gives way everywhere; what easily divides and disperses itself; what easily concentrates and collects itself; what easily flows and sets in motion; what easily sticks to another body and wets it; and what is easily reduced to liquid or is melted when it was consistent before. Thus when you come to predicating or imposing this term, if you take it in one way flame is moist, if in another air is not; if in another fine powder is moist, in another glass; so that it easily appears that this notion has been rashly abstracted without any due verification only from water and common, everyday liquors.³⁷

Aristotle himself might have responded to this charge by observing that the many definitions of moist are problematic only if he equivocates among them. That is true enough, but it misses the fact that Bacon is making an observation about the cause of equivocation. Equivocation does not ordinarily occur because people use a word to refer now to one well-defined notion and now to another, but because they have a single unclearly defined notion that they refer to each time. If our notions were always well-defined, equivocation would always be laughable rather than persuasive.

³⁶For an interesting development of the idea that notions or concepts just are a certain kind of mental policy of integration, see the unpublished Salmieri, "Justification as an Aspect of Conceptualization".

³⁷*N.O.* I. 60.

As Bacon observes, notions support predications. Justified notions allow for justified predications, whereas poorly abstracted notions lead to unjustified predications. Flame seems moist because it lacks firm boundaries, but it also seems dry because it dries things rather than wetting them, and as a result our beliefs about whether flame is moist are just as shaky and unjustified as our notion of “moist.” Since an instance in a natural history is just a predication, we cannot understand how sense-perception supports the instances in the natural histories without understanding the intermediary notions.

4.3.1 Which Notions are First-Level?

In forming many of our notions, according to Bacon, we can justifiably rely on prior notions and beliefs. I want to argue, however, that Bacon is committed to the existence of a special category of notions—I will use the term “first-level notions”—the formation of which can be justified directly by sense-perception, so that these notions do not depend epistemically on any other notions or on any beliefs. I will also use the term “properly basic belief” to refer to a justified belief that is not justified by other beliefs.³⁸ For Bacon, properly basic beliefs depend epistemically on the notions that enter into them,³⁹ and both first-level notions and properly basic beliefs depend epistemically on sense-perception, so it is important to remember that no notions or beliefs are absolutely primary. First-level notions and properly basic beliefs are the primary items of their respective categories, but not the primary truth-evaluable items (but remember that “truth” has a distinctive meaning when applied to sense-perception: a sense-perception is true if and only if it causally registers some mind-independent object).

³⁸For a more complete and precise set of definitions of terms relevant to Bacon’s foundationalism, see p. 122 in 4.5. Also, note that when talking about our most basic ideas, Bacon tends to use categories such as “particulars,” “instances,” or “propositions” rather than the more psychological category, “beliefs.” But I regard this largely as a difference in emphasis, and I think it is useful to frame the discussion in terms of “beliefs” in order to facilitate comparisons with contemporary views in epistemology.

³⁹It is worth citing this passage again: “The syllogism is made up of propositions, propositions of words, and words are markers of notions. Thus if the notions themselves (and this is the heart of the matter) are confused, and recklessly abstracted from things, nothing built on them is sound” (*N.O.* I. 14).

The language of “first-level notions” is not Bacon’s, but with a little work we can show that he is gesturing towards the idea of first-level notions when he says, “Notions of the lowest species [*infimarum Specierum*]*—Man, Dog, Dove—*and of the immediate impressions [or apprehensions, *prehensionum*] of sense—*Hot, Cold, White, Black—*are not very misleading, but these too are sometimes confused by the flux of matter and the intermingling of things.”⁴⁰ Similarly, when discussing the idols of the marketplace, he says that some notions are less badly abstracted than others, and some words are correspondingly less problematic than others. “The least bad is the kind comprising the names of a particular substance, especially those of the lowest or well-deduced species (for the notion of chalk and mud is good, of earth bad); a worse kind comprises actions, as *to generate, to corrupt, to alter*; the worst kind comprises qualities (save for the immediate objects of sense) as *heavy, light, tenuous, dense, etc.*”⁴¹

I suggest that there are two categories of notions that Bacon regards as first-level in the sense I have defined. First are *infima species*, which is a term straight out of Aristotle and the scholastics. These lowest, indivisible, or uncuttable species (*atoma eidei* in the Greek) differ from other species in that they are the only ones which cannot themselves become genera relative to some narrower species. Any narrower divisions involve the specification of accidents. For example, one can divide men into white men and black men, but color is not causally significant enough for these to count as distinct kinds.

Second are the immediate apprehensions of sense-perception. Note that these are not identical to the notions of qualities pursued in Part Four of the *Instauratio*, which we just saw Bacon refer to as the most poorly abstracted notions. When Bacon talks about the notion of “hot” as one that doesn’t usually lead us astray, he cannot mean that it is obvious that heat is a kind of motion. Initially, we group instances of heat together not because they are all instances of a certain kind of motion, but because they all feel similar.⁴² If one were to give words to

⁴⁰*N.O. I.* 16.

⁴¹*N.O. I.* 60.

⁴²Instances, as in the table of presence concerning heat in the *Novum organum*, are initially grouped together because of the similarity in their effects. Some instances might be included because of their similarity in their effects on entities other than ourselves, but I think that this

the notion of heat at this early stage, one might say, “Heat is what I feel when I put my hand to the fire, or when I step into the sun, or when I shake your hand. Anything that feels like *that* is heat.” But Bacon does not seem to think that this early notion of heat must be replaced or overturned by the notion of heat as a kind of motion, as if it were in error. It seems, rather, that it is possible for the two notions to co-exist. Heat (as a kind of feeling) and heat (as a kind of motion) are polysemes; the identical word signifies distinct *but related* notions.⁴³ When Bacon introduces his definition of heat as a kind of motion, he says, “Now from this First Vintage, the form or true definition of heat (i.e., of heat relative to the universe and not just relative to the sense) is, put briefly, this.”⁴⁴ He does not say that the notion of heat relative to sense was wrong; that just isn’t what he is defining.

So we have two categories of notions that Bacon regards as “not very misleading,” notions of *infima species* and of immediate apprehensions. But are they first-level? Aphorism I. 16, by itself, only establishes that we make fewer errors with regard to these notions. It does not explain why we make fewer errors. Is it because they are first-level notions? Or could there be some other reason why these, the least abstract notions, are also the least prone to error? (As a first approximation, by abstraction I mean the process of mentally isolating some particular instances as of-a-kind. Sometimes, we isolate a class of instances by distinguishing it from another related class that we have already isolated. In that case, the new class is more abstract. For a fuller account of abstraction, see 4.2.2, where I note that abstraction can involve creating a narrower notion as well as a broader one, as well as 4.3.3 where I discuss the mechanism of abstraction.)

sort of similarity is more likely to come into play after one already has an initial notion that is based on feeling alone, i.e., on the similarity in their effects on *us*.

⁴³A polyseme is a word that has multiple, closely related meanings. For example, the word “open” is a polyseme in the following sentences: “The door is open” and “I am open to new experiences.”

⁴⁴“*Ex Vindemiatione autem ista prima, Forma siue Definitio vera Caloris (eius, qui est in ordine ad Vniuersum, non relatuus tantummodo ad Sensum) alis est, breui verborum complexu*” (*N.O.* II. 20, 2 B4^r22). See also Bacon’s work *Thoughts and Conclusions*, translated in Farrington, *The philosophy of Francis Bacon: an essay on its development from 1603 to 1609*: p. 99: “The understanding is endowed by nature with an evil impulse to jump from particulars to the highest axioms (what are called First Principles). This impulse must be held in check; but generalisations lying close to the facts may first be made, then generalisations of a middle sort, and progress thus achieved up the successive rungs of a genuine ladder of the intellect.”

I will argue that the reliability of notions of *infima species* and of immediate apprehensions is indeed a result of their first-level status. There is, however, at least one plausible alternative explanation, namely, that as notions become more abstract, there are more ways in which they can become idols (the false notions and axioms which Bacon discusses in the first book of the *Novum organum*), so that the least abstract notions are the least susceptible to the causes of the idols, even if they are not treated by Bacon as first-level in the sense of being based directly on sense-perception. For example, idols of the theater, which are the false notions and axioms caused by flights of fantasy in philosophical texts, tend to be very abstract. Plato's *Phaedo* teaches us about the soul and recollection, not about "man" or "white."

We need additional evidence that the least abstract notions are first-level.

4.3.2 Gradualism and First-level Notions

I will argue that Bacon's gradualism implies that the least abstract notions are first-level.⁴⁵ His principle of gradualism is stated in the following passage:

There are and can only be two ways of investigating and discovering truth. The one rushes up from sense and particulars to axioms of the highest generality and, from these principles and their indubitable truth, goes on to infer and discover middle axioms; and this is the way in current use. The other way draws axioms from sense and particulars by climbing steadily and by degrees so that it reaches the ones of highest generality last of all; and this is the true but still untrodden way.⁴⁶

This passage *seems* to identify the hierarchy of generality—the ordered sequence of ideas from narrowest to most general—with the proper hierarchy of discovery.

⁴⁵One of the more extensive discussions of Bacon's gradualism is by Urbach: "[Bacon] thought that theories could acquire, through experiment, a high degree of certainty. As a rule, the more general a statement is known to be, the less certain it is, for the stronger of two statements make [*sic*] the more claims. It follows that the more general a theory is, the more evidence it will require before it can be accepted." Urbach, *Francis Bacon's Philosophy of Science: An Account and a Reappraisal*: p. 55. As will become evident, I think Urbach misidentifies both the content of Bacon's principle of gradualism and his reason for holding it. More abstract notions and axioms are less certain, at first, because they epistemically depend on less abstract ones, not because they make more claims.

⁴⁶*N.O.* I. 19.

(But see p. 111 below for an important distinction between degrees of generality and degrees of abstractness. The relevant hierarchy is better characterized as a hierarchy of abstraction.) Something along these lines would be useful in establishing that the least general ideas come first in the order of discovery.

This passage is somewhat misleading, though, since Bacon does think that we often need to appeal to notions and axioms of higher generality in order to support notions and axioms of lower generality (more on that later). We need to take a quick detour and consider how we can interpret this aphorism in a way consistent with the fact that Bacon does not call for Interpreters of Nature to proceed in a linear manner.

Notice first how Bacon characterizes the method opposed to his own. It “rushes up from sense and particulars to axioms of the highest generality and, from these principles and their indubitable truth, goes on to infer and discover middle axioms.” Bacon does not object to using highly general hypotheses to infer and discover lower axioms. He does not even object to highly theoretical speculation, as long as one regards the conclusions reached thereby as tentative and uncertain. Remember that Part 5 of Bacon’s own *Instauratio* is devoted to anticipations of nature. So what he must object to is the practice of exceeding “due degrees of certainty,” as when we take the highest generalities as certain and then rely on syllogisms to deduce everything else: “in the *Interpretation of Nature* the mind must surely be prepared and shaped in such a way as not to exceed due degrees of certainty, and yet understand (especially at the start) that what it has done very much depends on what it remains to achieve.”⁴⁷ These considerations suggest that Bacon’s principle of gradualism amounts to the thought that abstract notions and axioms are no more certain than the more particular notions and instances from which they are induced:

The Principle of Gradualism: One must secure items of lesser abstraction to degree of certainty X before attempting to secure any items of greater abstraction to the same degree X.

Although it is fine to speculate about what life is before one is very clear what plants and animals are, one must regard that speculation as no more certain than

⁴⁷N.O. II. 19.

one's notions of plants and animals.⁴⁸

It is important to note, as far as applying this principle goes, that one should draw a distinction between degrees of abstraction and degrees of generality. In a sense, notions of *infima species* and of the immediate apprehensions of sense-perception are not the narrowest or least general notions, but they *are* the least abstract. The *infima species* “man” can be divided into “white man” and “black man,” and the immediate apprehension “white” can be divided into various shades, such as “cream” and “ivory.”⁴⁹ The latter categories are extensionally narrower. We have to remember that those subcategories are also more abstract (they are abstracted from the larger category) and they cannot be any more certain than the component notions, just as, according to Bacon, an axiom cannot be any more certain than the notions that enter into it. (It is not clear to me how Bacon would handle subcategories of immediate apprehensions, but I think his best move would be to handle them in the same manner. Subcategories of “white” such as “cream” or “ivory” are formed by noticing something that locates them within the larger category, so that the notions “cream” and “ivory” depend on the notion “white” and are not themselves notions of immediate apprehensions.

So Bacon's point in I. 19 is that the scholastics go wrong by trying to attain a high degree of certainty in the most abstract notions and axioms *before* they have secured less abstract notions and axioms to the same degree of certainty, and they instead try to deduce the less abstract, “middle axioms” from the more abstract ones. The reason this is wrong is that more abstract notions and axioms epistemically depend on less abstract ones, and when one item epistemically depends on another, it can be no more certain than it is. This is an application, within the context of a system that allows for degrees of certainty and inductive support relations, of a thesis which Alvin Plantinga attributes to all foundationalists, namely,

⁴⁸Note that one might not have to be certain to degree X what a table is or what sugar is before being certain to degree X what life is. The hierarchy of generality has the structure of an upside down tree, in which items on different branches may be independent of one another.

⁴⁹It is possible that Bacon thinks that notions of immediate apprehensions are, in the case of colors, shade-specific. So the notion of “white” would be a notion of “pure white” and thus not divisible into further shades. If this is Bacon's view, then the problem I am discussing here does not arise for notions of immediate apprehensions. However, I do not find it plausible that we can form a notion of “pure white” immediately.

that “warrant does not increase just by virtue of warrant transfer.”⁵⁰ And depending on the strength of the inferential relationship, it might be just as certain as it is, a little less certain, or a lot less certain.

From the principle of gradualism, thus understood, we can infer that notions of *infima species* and of immediate apprehensions are first-level since they are the least abstract notions. Anything more specific is more abstract, and anything more general is also more abstract. (And lest we doom Bacon to idealism, let us not try to abstract notions of *infima species* from notions of immediate apprehensions.)

Note that the principle of gradualism does not imply the lack of any epistemic dependence of notions of *infima species* or of immediate apprehensions of sense-perception on more abstract notions. Bacon does think that these two kinds of notions can go on to be confirmed or even revised. But given that Bacon regards them as already strongly justified, in spite of all the uncertainty and falsehood of more abstract notions, they don’t take their initial evidence from those more abstract notions. Instead, they are abstracted directly from observed particulars (in a manner that I will discuss in 4.3.3).

I hasten to add that Bacon himself warns that even the notions that I am calling first-level are sometimes confused by the flux of matter. As Ellis aptly explains this point, “Bacon means that the union of bodies of different kinds, by giving rise to new qualities and species intermediate to those for which we have recognized names, tends to confuse our ideas of the latter.”⁵¹ Although, for example, we have a more or less clear notion of a dog that is based on everyday experience, we can become confused when we first encounter a wolf, and then a hyena, and so on. Natural kinds, if we can call them that, shade into one another without discrete borders. The upshot is that our first-level notions are certain enough to allow us to proceed to higher levels of abstraction, but we may need to circle back and confirm or revise them at some point. They are strongly justified from the start, but not necessarily conclusively so.

⁵⁰Plantinga, *Warrant: The Current Debate*: p. 76. This is Plantinga’s explanation for the foundationalist rejection of circular reasoning.

⁵¹Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 1, p. 244.

4.3.3 The Nature and Justificatory Force of the Abstraction of First-level Notions

On what basis can we say that first-level notions are strongly justified from the start? Why does the process of abstraction confer any degree of justification on its products? It is difficult to say much with certainty about Bacon's view of how first-level notions are abstracted. Is there a notion before there is a definition? Before there is a word? Are there different options for how to start off? Do the first-level notions vary depending on one's surroundings or culture, so that some of the notions of colors which might be first-level for the Inuit are not first-level for us, for example? Volumes can be written (and have been written) in response to these and similar questions, but they would have to go far beyond anything in Bacon's corpus.

Nevertheless, we can infer a few things about what kind of account of the abstraction of first-level notions he would be able to accept, given some of his other commitments: (1) He denies any mind-independent reality to universals, but nonetheless holds that notions are truth-evaluable on account of real similarities and differences in the world.⁵² (2) Natures differ along quantitative continua. (3) Sense-perception, as I discussed in Chapter 3, is a difference-detector. I will discuss these points in turn.

Bacon is explicit about (1). Plato is his target here:

Yet have I not forgotten what I noted and corrected above as an error of the human mind in denouncing the view that forms are primary essences. For although nothing really exists in nature besides individual bodies carrying out pure, individual acts according to law, yet in the sphere of doctrine, this very law, and the investigation, discovery and explanation of it, is the very foundation of knowing as it is of operating. It is this *law* then, and its *clauses*, that I understand by the name of forms.⁵³

⁵²I will avoid such classifications as “nominalism” and “conceptualism” on the grounds that different writers use these terms in different ways and sometimes imbue them with metaphysical significance and sometimes with epistemological. With regard to metaphysics, Bacon denies that universals exist altogether. Presumably, he would even offer a largely materialist account of the mind. What is general or universal about notions is not their metaphysical status, but just the fact that they *refer* generally to a number of particulars that are similar.

⁵³*N.O.* II. 2.

There are no universals in nature, then. No two bodies and no two actions are identical. Yet bodies, in their actions, follow laws. For Bacon, these laws take the form of definitions, and those definitions, he thinks, can be either true or false; they either correspond to the world or they do not. That is, there is a fact of the matter about which things in the world are similar and about the nature of that similarity. Whatever Bacon's account of abstraction, it will have to be consistent with his denial of mind-independent universals and with his belief that definitions can either succeed or fail to latch onto the real similarities among particular things.

One account that he could accept is suggested by the next point: natures differ along quantitative continua. Take simple natures first. Heat, motion, whiteness, and all the other simple natures are present in things to varying degrees. This is the rationale behind Bacon's table of degrees: "we must submit to the *tribunal of the intellect* instances in which the nature under investigation exists to a greater or lesser degree, and this is done either by comparing its increase or decrease in the same subject, or its intensity in different subjects compared one with another."⁵⁴ And Bacon make this connection between natural kinds and quantitative degrees of natures even more explicit when he discusses "*Subjunctive Instances*," or "*Instances of an Ultimate State or Limit*." These instances

point quite openly to the real dividing lines of nature, to the measures of things, to that *How Far* a nature may do or suffer anything, and afterwards to the transitions of one nature into another. Examples of this are gold in weight; iron in hardness; the whale in animal size; the dog in scent; the firing of gunpowder in rapid expansion; and other things of the kind. And no less should we notice limits of the lowest degree than of the highest: as spirit of wine in weight; silk in softness; skin worms in animal size, etc.⁵⁵

Since our definitions of each nature must capture all of the instances, from the lowest degree to the highest, it is important to take note of these limits by including extreme instances in our tables, such as the densest material that exists or the largest animal that exists. A little less obvious, but no less important, is the meaning of Bacon's talk of "the transitions of one nature into another." His own

⁵⁴*N.O.* II. 13.

⁵⁵*N.O.* II. 34.

examples confuse the point. After all, if an animal had a more discriminating sense of smell than a dog, we would not say that that animal no longer has the property of being able to smell and has started to transition into having some other property. And similarly, if we found something heavier, i.e., denser, than gold, we would not say that that entity no longer exhibits the property of density.

This difficulty leads me to think that the point about transitions is supposed to apply to compounded natures, not directly to simple ones. This would explain why Bacon says that Instances of an Ultimate State point to transitions *after* pointing to the dividing lines of nature—because we have to analyze compounded natures in terms of simple ones. Another one of the prerogative instances, Frontier Instances or Participles, reinforces that interpretation:

Now these are the ones which exhibit species of bodies which seem to be made up of two species, or to be *Rudiments* between one species and another [...] they are extremely good at pointing out the composition and structure of things, and at suggesting causes for the number and quality of ordinary species in the universe, and at leading the intellect from what does exist to what may exist. Examples of them are these: moss between putrefaction and plant; some comets between stars and fiery meteors; flying fish between birds and fish; bats between birds and quadrupeds; and also *The ape, the most degraded creature, yet so like us*, and biform births of animals made up of different species, and so on.⁵⁶

It sounds very much like Bacon is talking about transitions from one nature to another here, and sure enough the examples are all of compounded natures rather than simple ones: moss, comets, bats, etc. This suggests a way to extend our interpretation of the passage about subjunctive instances. The point is not that some dogs are more dogs than others or that if there is ever an animal larger than a whale, it lacks the property of animal size, but that because substances just *are* conjunctions of simple natures, and each of those simple natures varies in degree, those compounded natures can also be compared quantitatively. Animals, for example, differ from one another along various quantitative continua: their size, their swiftness, the sensitivity of their sense of smell, and so on, and when all

⁵⁶N.O. II. 30.

of those dimensions of quantitative variation are taken into account, we find that flying fish reside midway between birds and fish, that bats reside midway between birds and quadrupeds, and so on. A true notion, therefore, is one that accurately reflects the commensurability and the relative quantitative proximity of the things in a category in contrast to other things that are relatively quantitatively distant.

When we combine this account of the truth-evaluability of notions with Bacon's account of sense-perception, we can see why abstraction from sense-perception can confer some degree of justification on its products. Since sense-perception is a difference-detector, one way to understand the process of abstraction would be as a process that begins with sense-perception presenting natures to us as either nearer to or further from each other based on the magnitude of their perceptual differences. So to abstract the notion of "dog," we focus on a number of the characteristics of the animals that we have seen. Sense-perception registers the differences in size among those animals, so elephants strike us as very different from dogs and cats along the continuum of size. It also registers differences with respect to swiftness, so that dogs strike us as something different from turtles along that continuum. This perceived quantitative similarity of the instances is what justifies the abstraction of a first-level notion.⁵⁷ (When we come to notions that are not first-level, the abstraction will have to be justified by similarities that require thought to grasp, but the rest of this account will remain the same.)

This claim requires an important addition to the account of sense-perception in Chapter 3. If the difference-detecting ability of sense-perception informed us only that *if* there is a change in sense-perception, *then* there must be some (but *any*) change in the world, then sense-perception would not provide us with epistemic access to objective quantitative relationships. That is all well and good, per-

⁵⁷Don Rutherford wonders whether this account implies that enumerative induction, involving the repeated observation of instances of a kind, is involved in the formation of first-level notions. What I think we should say here is: (1) It is not enumerative induction. Enumerative induction requires that one *already* have a notion that refers to all of the instances enumerated. (2) It is, however, analogous to part of Bacon's method of induction—specifically, to the work performed by the prerogative instances dealing with natural kinds. See p. 191 in 5.2.3. (3) Since first-level notions are abstracted without a conscious method, though, the best we can say is that the process is implicitly inductive. We engage automatically in the similarity- and difference-detecting work which later on we will try to engage in deliberately.

haps, when it comes to notions of the immediate apprehensions of sense-perception. These notions are supposed to be relational; it is enough to categorize all instances of heat together, at first, if there is always a greater or lesser quantity or intensity of the same sensation, in every instance of heat. But, as I have indicated, our notions of *infima species* are not all relational. We don't have two different notions of "dog," one of "dog-as-it-relates-to-us" and the other of "dog-as-it-is-objectively." Therefore, it seems that Bacon is required to hold, at least insofar as notions of *infima species* are non-relational, that the perceived magnitude of differences or changes corresponds in a rough way to their actual magnitude. Because first-level notions are revisable and pertain only to the easiest, most obvious cases, we don't need sense-perception to be perfect here.⁵⁸

4.4 The Initial Justification of Natural History

If Bacon is following a moderate foundationalist method, then we would expect to find many instances in the natural histories which receive some initial justification independently of any hierarchically posterior notions and axioms. The purpose of this section is to show that there are such instances and to explain some of the typical ways in which they are justified. Note that I am not treating Bacon's natural histories as examples of such first iteration histories but rather using Bacon's methodology in conjunction with his histories to reach a judgment about what the first iteration should look like, even if parts of that first iteration history need not be written down.

First, we need to bridge the gap between first-level notions and claims in the natural histories. The principle of gradualism applies just as much to propositional beliefs as it does to notions: one should not seek degree of certainty X about a principle or generalization until one has first established with at least that degree of certainty the notions and the particular instances that support the generalization.

⁵⁸Bacon probably holds (and I think ought to hold) that error is possible even for our notions of immediate apprehensions, which would set him apart from the common early modern viewpoint that we can at least avoid making errors by restricting ourselves to the contents of our own minds. For example, our initial classification of spicy food as hot might fail to capture qualitative differences between spiciness and fire that sense-perception registers but which we fail to notice.

This is why I say that Bacon is implicitly committed to the existence of basic beliefs, and as I hinted at above, many basic beliefs involve appealing directly to notions to support predications. The first-level notion of heat together with the observation of a fire justify the presumably basic belief that the particular fire being observed is hot.

Accordingly, natural history begins with particular instances:

History is properly concerned with individuals, which are circumscribed by place and time. For though natural history may seem to deal with species, yet this is only because of the general resemblance which in most cases natural objects of the same species bear to one another; so that when you know one you know all.⁵⁹

The word “properly” seems to be doing a lot of work in this passage since elsewhere, in the *Descriptio globis intellectualis*, Bacon’s emphasis is the other way around:

Natural history is not about single objects, which is not to say that I was wrong to lay down that history is concerned with individuals located in space and time. For properly that is how things are. But since there is a casual likeness among natural things such that if you know one you know all, it would be a waste of time and effort to speak of singulars. Therefore wherever that casual likeness is lacking, natural history does indeed admit individuals, those, that is, that do not belong to a troop or kind of nation.

In keeping with this latter passage, Bacon’s own natural histories are not simply records of isolated perceptual reports and contain few propositions that would plausibly be basic; instead, they are filled mostly with summaries of the typical behavior of things and even with low-level generalizations (justified in part, as Bacon indicates here, by the general resemblance of things that belong to a species). Bacon feels no need to dwell on propositions about individuals (except when there is something special or unique about them)—e.g., “That dog is barking,” “That fire is hot,” and “That water is up to my ankles”—because for the purpose of developing a natural history, we can skip these over and proceed to slightly more general propositions.

⁵⁹*De augmentis*, Vol. 4, p. 292.

But this feature of natural history leaves us with a puzzle. Bacon seems to regard many of the generalizations in his natural histories as certain, including some that are founded mostly on the testimony of reputable sources. Let us look at some examples of instances that he regards as certain. Some of them are generalizations, and some are not.

- (a) In salt water, the saltier part of the water sinks to the bottom.⁶⁰
- (b) Putting pressure on parts of animals, when the animals are very young, alters their shape as they grow.⁶¹
- (c) Fats, like olive oil, when applied to the skin close up the pores and diminish the amount of sweat that comes through.⁶²
- (d) “It is certain (howsoever it cross the received opinion) that sounds may be created without air” [i.e., in a medium other than air].⁶³
- (e) “it is certain that the voice doth pass through solid and hard bodies, if they be not too thick; and through water.”⁶⁴
- (f) “it is certain that the cannibals in the West Indies eat man’s flesh.”⁶⁵
- (g) “It is certain that in the Peruvian mountains that at the same time winds often blow in one direction up the mountains, but in the opposite one in the valleys.”⁶⁶
- (h) “Certainly if one goes over the memorials of things, it appears from many remains and monuments (in Sicily and in some other places) that men’s heights and sizes were once much greater than they were in later ages.”⁶⁷

⁶⁰ *Sylva sylvarum* in Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 2, p. 340.

⁶¹ *Ibid.*: p. 349.

⁶² *Ibid.*: p. 362.

⁶³ *Ibid.*: p. 397.

⁶⁴ *Ibid.*: p. 401.

⁶⁵ *Ibid.*: p. 348.

⁶⁶ Bacon, *The Instauration magna: Part III: Historia naturalis*: M1^r 27.

⁶⁷ *Ibid.*: R7^v 26.

Those instances that are not generalizations are a little less problematic since the assertion that something occurs sometimes or often can't be overturned even if a counterexample were to turn up later. Of course, that does not mean they are straightforwardly certain. The certainty of some of them might depend on the revision mechanisms that I will discuss in 4.5.

But the generalizations, as I said, seem to pose a unique problem. Take (b), for example, the claim that putting constant pressure on developing animals alters their shape. Many instances can be cited in support of this claim, some of which are well-known today (such as the use of neck rings in certain cultures to create the appearance of a longer neck). The skeptic might object, however, that Bacon seems to claim with certainty that pressure always has this effect. Is it not possible that there is some unique animal out there that is resistant to the effects of pressure? Perhaps more certainty about the nature of pressure and of animals would help rule out that possibility, but Bacon does not seem entitled to claim that degree of certainty yet. A similar difficulty emerges after a glance at Bacon's tables concerning heat in the *Novum organum*. In listing instances where heat is present, Bacon mentions "all flame," "all things hairy," and "every body vigorously rubbed," among other categories.⁶⁸

The key here is to realize that, as a rule, the generalizations in Bacon's natural histories are intended to be rough generalizations along the lines of what he describes in the *Novum organum* under the heading of Instances of Companionship and of Hostility.⁶⁹ An Instance of Companionship is a set of observations of some subject or entity which reveals that some property belongs to the subject in every available case. An Instance of Hostility is a set of observations of some subject or entity which reveals that some property does not belong to the subject in any of the cases. Thus, the use of these instances amounts to enumerative induction. The generalization beyond the observed instances is supported by the general resemblance of things belonging to a kind. Unlike typical enumerative induction, however, the conclusion does not purport to be absolutely universal or unqualifiedly true. "Yet not even in these universal propositions," Bacon says of

⁶⁸*N.O.* II. 11.

⁶⁹*N.O.* II. 33.

such instances, “do we require precise or absolute affirmation or negation.”⁷⁰ Because of this, an exception does not overturn such a generalization or imply that it was ever uncertain.⁷¹ Unless Bacon states explicitly that a generalization in his natural histories holds without qualification (as he does now and then), we should assume that it is a rough generalization.

Returning to the generalization about the effects of pressure on animals, how does Bacon know that there is not some unknown animal that is resistant to the effects of pressure? Well, he does not. The discovery of such an animal would have been welcome news to Bacon, though. That sort of discovery has a place in natural history as what he calls a deviating instance, which is an instance of an atypical member of a species where “nature strays and turns aside from her ordinary course.”⁷² Bacon regards these kinds of instances as adding to his knowledge about kinds rather than overturning it. His rough generalization about animals would remain true and would not need to be abandoned, and now, in addition, he would be able to investigate what explains the difference between this newly discovered animal and every other. (Not all generalizations are rough generalizations of this sort, of course. There is no implication here that it is impossible to engage in a hasty generalization. The point is just that the possibility of exceptions to generalizations at this early stage in the development of a natural history is compatible with some of those generalizations being certain.)

Bacon’s reliance on testimony is another potential source of skepticism. This is one issue, unfortunately, where Bacon has very little to say:

it should be mentioned withal whether he took it from report, oral or written (as most of Pliny’s statements are), or rather affirmed if of his own knowledge; also whether it was a thing which happened in his own

⁷⁰Ibid.

⁷¹We must avoid confusing the content of a proposition with its epistemic status. “The flipped coin has a 50% chance of landing on heads,” has a probability for its content, but this does not by itself mean that one cannot be certain of the proposition as a whole. Similarly, a generalization can be merely rough with regard to its content but certain with regard to its epistemic status. In relation to this issue, consider the debate surrounding Hume’s missing shade of blue. Here is another case in which one might at least make an argument for continuing to uphold a generalization (Hume’s principle that ideas are copies of impressions) despite the discovery of an exception (an idea of a specific shade of blue that has never been seen before).

⁷²*N.O.* II. 29

time or earlier; and again whether it was a thing which, if it really happened, there must needs have been many witnesses; and finally whether the author was a vain speaking and light person, or sober and severe; and the like points, which bear on the weight of the evidence.⁷³

It is not clear exactly which combination of factors would entitle us to be certain of someone else's testimony, or why, but Bacon seems to think the issue is not that important since errors will be taken care of when the process of self-correction kicks in.

4.5 Scaffolding and Revision Mechanisms

A strictly linear process of inference would leave many errors and omissions in natural history since there are errors even among first-level notions and basic beliefs, according to Bacon. For a Cartesian foundationalist, for whom nothing can be absolutely certain unless it is inferred from something basic in an unbroken chain of deductive inferences, this is an insoluble problem. If a belief is mistaken, then every belief derived from it is undermined. Derivative beliefs further down the chain could never be used to justify beliefs earlier in the chain. What we need, Bacon says in effect, is a system of scaffolding that allows us to move up and down continuously, ascending to higher levels of the structure, ascending beyond natural history, in fact, before we can be fully sure that the lower levels are fixed in place.

This makes Bacon a moderate foundationalist, then. It is worth giving a fuller statement of what I take moderate foundationalism to involve.⁷⁴ Moderate foundationalism is a theory of the structure of the justification of our knowledge which holds that this structure is hierarchical and begins with foundational, strongly justified beliefs. To put this more precisely, we may define a non-basic belief as one which we regard as justified based on other beliefs, a basic belief

⁷³Bacon, *The Instauration magna Part II: Novum organum and Associated Texts: Parasceve* 8.

⁷⁴My account of foundationalism closely follows the influential account in Plantinga, *Warrant: The Current Debate*: pp. 67-72. My account of moderate foundationalism in particular is based additionally on Bonjour, *The Structure of Empirical Knowledge*: p. 26. "According to moderate foundationalism, the noninferential warrant possessed by basic beliefs is sufficient by itself to satisfy the adequate-justification condition for knowledge [...] Historical foundationalist positions typically make stronger and more ambitious claims on behalf of their chosen class of basic beliefs."

as one which we regard as justified based on any factor aside from other beliefs, and a properly basic belief as one which actually is justified by some factor aside from other beliefs. (Something may be a basic belief even if it is unjustified, as long as we *regard* it as justified; to be properly basic, a belief must be regarded as justified by factors aside from other beliefs *and* actually be so justified.) Given these definitions, moderate foundationalism holds that (1) our justified beliefs fall into two categories, those which are properly basic and those which are not; (2) non-basic beliefs must be justified either by basic beliefs or by a chain of non-basic beliefs that ends in properly basic beliefs, (3) the level of justification required for a belief to be properly basic is not certainty but some level of strong justification which falls short of certainty; and (4) beliefs that at one time are properly basic can receive additional justification from beliefs higher in the hierarchy of justification.⁷⁵ On this account, (1) and (2) are features of all forms of foundationalism, while (3) and (4) are the distinguishing features of moderate foundationalism.

4.5.1 Degrees of Certainty

To use scaffolding in the development of science means, first, that one has to be cognizant of the degree of certainty of all of one's ideas. That is not to say that Bacon thinks one must assign a numerical probability to any of them. It is not clear that Bacon would even consider this possible. Rather, he thinks it is important to characterize the degree of certainty in a rough, qualitative way that will guide the ensuing revision process. This demand applies throughout most of the *Instauratio*. It applies to natural history: "With regard to the credit of the things which are to be admitted into the history, they must needs be either certainly true, doubtful whether true or not, or certainly not true. Things of the first kind should be set down simply. Things of the second kind with a qualifying note, such as, 'it is reported,' 'they relate,' 'I have heard from a person of credit,'

⁷⁵As a terminological point, note that the beliefs would be non-basic after they receive this additional justification. For example, suppose B is a properly basic belief at one time. Later, another belief offers further justification for B. At this later time, B fits the definition of 'non-basic' that I offered above.

and the like.”⁷⁶ Bacon follows this advice in his own natural histories when he says, for example:

“Of ostriches we know nothing [about their lifespan] for sure.”⁷⁷

“The age of fish is less certain than that of land animals since, living under water, they have been less closely observed.”⁷⁸

“Winds happen in a thousand ways [...] thus it is not easy to establish observations in so varied a subject. Yet those that I have set down may be in general taken for certain.”⁷⁹

“Vaporous winds do not seem to blow at any great altitude, though it is nevertheless likely (*probabile*) that some of them climb higher than many clouds.”⁸⁰

“It is certain, that in the noise of great ordnance, where many are shot off together, the sound will be carried (at the least) twenty miles upon the land, and much further upon the water.”⁸¹

The same need to label the degree of certainty of one’s ideas applies to theoretical speculations that one might mix into one’s natural histories (but note that Bacon thinks that these speculations are properly speaking the province of Part Four of the *Instauratio* and that mixing these into a history renders the history impure):

I put forward speculations and, as it were, certain imperfect attempts at the interpretation of causes; I do this sparingly, more to hint at what might be the case than to determine what is the case. I outline and establish rules (yet only provisional ones), or imperfect axioms which crop up in the course of inquiry, and not with the intention of laying down the law.⁸²

In the *Historia vitae*, for example, Bacon includes a whole section of provisional rules (*CANONES mobiles de Duratione Vitae, & Forma Mortis*),⁸³ including:

⁷⁶Ibid.

⁷⁷*Historia vitae* in Bacon, *The Instauratio magna: Part III: Historia naturalis*: F7^r.

⁷⁸Ibid.

⁷⁹*Historia ventorum* in Bacon, *The Instauratio magna: Part III: Historia naturalis*: G8^r 18.

⁸⁰Ibid.: K7^r 9-11.

⁸¹*Sylva sylvarum* in Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 2, p. 208.

⁸²Bacon, *The Instauratio magna: Part III: Historia naturalis*: C5^r 31 - C5^v 2.

⁸³See the section beginning at 2C7^r 6.

“Rule 1: Consumption does not happen unless what is lost from one body takes up residence in another.”

“Rule 4: In all living things there are two kinds of spirits: non-living ones of the kind found in inanimate substances, and the superadded vital spirits.”

“Rule 11: Condensation of the spirits in their substance is good for longevity.”

And the same need for labeling also applies to the hypotheses about formal causes in Part Four of the *Instauratio*, where he calls such hypotheses First Vintages or provisional interpretations. Indeed, I believe that Bacon may have intended to use the terms Second Vintage, Third Vintage, etc., to designate the continued refinement of these hypotheses.⁸⁴

The need to be cognizant of the degree of certainty of one’s ideas even applies to Part Five, where Bacon uses the term “anticipation” to designate claims that are not reached by the Interpretation of Nature at all. And anticipations can be ranked as more or less flimsy depending on whether the person who arrives at them has guarded against the idols. (The fact that Bacon has guarded against the idols is what in his view legitimates his own anticipatory work.⁸⁵) Bacon seems even to hold that the methodological dictates of Part Two of the *Instauratio*—that is, the *Novum organum* itself—must be assigned an epistemic status and revised over time since “the art of discovering can grow as the number of things discovered

⁸⁴The evidence for this intention comes from William Harvey, who says, in his work *On Animal Generation*: “Wherefore I think it advisable here to state what fruits may follow our industry, and in the words of the learned Lord Verulam, to ‘enter upon our second vintage.’” Harvey, *The Works of William Harvey, MD*: p. 270. Bacon does not use those words in any of his published writings, but Harvey was personally acquainted with Bacon and might know something that we do not. I first learned of this passage from McCaskey, “Regula Socratis: The Rediscovery of Ancient Induction in Early Modern England”: pp. 324-5. McCaskey uses the passage as evidence of Bacon’s influence on Harvey.

⁸⁵“I do not doubt that if anyone, though of moderate gifts but ripe judgment, could and would set aside the Idols of his mind and resolve to undertake the inquiry afresh, and involve himself attentively, diligently, and frankly with the truths of natural history and its accounts, he himself would be able, whoever he is, to penetrate much further into nature by himself using his own innate mental powers and, in short, by his own naked anticipations than by reading all kinds of authors, no end of abstract meditation, or regular and repeated disputation—even if he had not deployed the right machines nor followed the proper form of interpreting.” Bacon, *The Instauratio magna: Last Writings*: R2^v 17-26.

grows.”⁸⁶ This is because the method of induction itself is, in Bacon’s view, the product of induction, and it continues to refine and perfect itself in what he takes to be a virtuous circle.⁸⁷

4.5.2 Enhancement

For now, I will set aside everything but Part Three of the *Instauratio*. After degrees of certainty have been assigned to the instances in a natural history, there are four kinds of revisions that can take place: instances can be added, assigned a greater degree of certainty, assigned a lesser degree of certainty, or deleted. I find it useful to employ the term ‘enhancement’ for any sort of augmentation, i.e. for the first two kinds of revision. Enhancement, then, is the process by which a scientist adds to or expands the knowledge in a particular field by relying on what has been discovered so far, whether by drawing out the consequences of earlier discoveries or by performing experiments or employing instruments that were made possible by earlier discoveries. I also find it useful to use the term ‘self-correction’ for the second two kinds of revision, i.e., for the process by which a scientist assigns a lesser degree of certainty to an instance, or deletes it entirely, on the basis of discoveries made possible by the research program that formerly included those claims.

Enhancement works by means of what Bacon calls “the art of indication,” which he divides into two kinds, one which functions by means of what he calls “Literate Experience,” and another which works by inferring particular instances or experiments from the results of the Interpretation of Nature. (It is also possible to make new discoveries blindly, without using any conscious method at all.) Here is how Bacon breaks it down:

This Art of Indication (for so I call it) has two parts. For the indication either proceeds from one experiment to another; or else from experiments to axioms; which axioms themselves suggest new experiments.

⁸⁶I have replaced “will” in the Rees translation with “can.” “*Artem Inueniendi cum Inuentis adolescere posse, statuere debemus.*” *N.O.* I. 130.

⁸⁷Figure 4.1 can account for some but possibly not all of this refinement. Some axioms pertain to methodology, and these can be revised even within the context of that diagram. However, if there are more radical methodological shifts, then aspects of the diagram itself might have to be revised.

The one of these I will term Learned Experience, the other Interpretation of Nature, or the New Organon. [...] Nevertheless as a man may proceed on his path in three ways: he may grope his way for himself in the dark; he may be led by the hand of another, without himself seeing anything; or lastly, he may get a light, and so direct his steps; in like manner when a man tries all kinds of experiments without order or method, this is but groping in the dark; but when he uses some direction and order in experimenting, it is as if he were led by the hand; and this is what I mean by Learned Experience. For the light itself, which was the third way, is to be sought from the Interpretation of Nature, or the New Organon.⁸⁸

Literate experience (*experientia literata*, sometimes translated Learned Experience) is a technique whereby existing instances suggest new instances, without the mediation of axioms, so that one can add those new instances to one's natural history (or derive from them new works to enhance human life, although that is not my focus here). Table 4.1 summarizes the techniques involved:⁸⁹

⁸⁸*De augmentis*, Vol. 4, p. 413

⁸⁹Based on Bacon's discussion in *ibid.*: pp. 413-21.

Table 4.1: Literate Experience

Types of Literate Experience	Subtypes or Descriptions	Examples
Variation	Vary existing instance by altering: (a) Material cause or (b) Efficient cause or (c) Quantity	Paper can be made from linen. Can it be made from silk? Magnified rays of sunlight can create flame. Can the moon's rays? A one pound ball falls in five seconds. How long for a ten pound ball?
Production	Repetition: repeat the process Extension: look for something more fine-grained or subtle	After distilling wine to get spirit of wine, perform a second distillation on the spirit of wine. A compass points north. Does it get there by turning eastward or by turning westward?
Translation	Importation of an experiment: (a) From nature to art (b) From one art to another (c) From part of an art to another part of the same art	From a rainbow to prisms From embalming materials to cosmetics
Inversion	Try the contrary experiment	Magnifying glasses concentrate heat. What about cold?
Compulsion	Try to destroy the power of the cause	Magnets attract iron. Does submerging them in acid stop this?
Application	Practical use of one experiment within another	Flesh putrefies faster in a damp cellar. What does this say about the best weather?
Conjunction	Increase the power of something by joining it with something else	Increase the refrigerating power of ice by joining it with nitre.
Chances	Try something on a hunch, just because it hasn't been tried before	Fill an airtight container with a substance and heat it in the furnace.

Take Bacon's example of inversion. We already know that magnifying glasses concentrate the heat from the sun's rays. This is certain and is included as a fact in our natural history concerning heat. But now we turn our attention to our natural history concerning cold and notice that it is relatively empty of instances and experiments. One way to populate it with new instances and experiments is to take those relating to heat and to invert them. Then we can record that a magnifying glass either does or does not concentrate cold. Thus, natural history can fill in its own gaps.

Literate experience also plays a role in adding to the certainty of existing instances. Consider the instance from the *Sylva sylvarum*, mentioned earlier, that sound can be created without air. His first piece of evidence is the instance that tongs, when struck together underwater, still produce a sound. This seems to be the initial instance. By itself, however, it is not fully persuasive. Might there not be air dissolved in the water? Perhaps this is why Bacon mentions a second instance, one which he comes to by using the technique of varying the experiment (specifically, varying the material). He strikes the tongs underwater in a silver vessel and in a wood vessel, and then he empties the vessels and strikes the tongs in the air within them. When there is water, the silver vessel resounds more than the wood one, but when there is air, there is no difference. Bacon infers that the vessel itself must be resounding and that water is *better* than air at communicating the sound to the vessel. Thus, this second instance allows Bacon to have more certainty in the initial claim that sound can be created without air. If water is better than air at communicating sound, then it would be surprising if it were dissolved air in the water that made the sound possible. (Bacon goes on to vary the experiment again by striking bodies amidst a flame.)

Or here is an example that Bacon has in mind when writing about heat in the *Novum organum*. One might include in a natural history concerning heat the tentative claim that the moon's rays are not hot. In order to add to the certainty of this claim, one can use a magnifying glass on the moon's rays and direct the magnified rays at a sensitive thermometer. If there is no effect on the thermometer, then one can simultaneously assign a greater degree of certainty to the claim about

the moon's rays and add a new, certain claim that the moon's rays, when passed through a magnifying glass, have no effect on a thermometer.

The other part of the art of indication works through the mediation of axioms, or at least provisional interpretations or speculations, discovered by the Interpretation of Nature. Because of a hypothesis that aging might be caused in part by a loss of moisture, we might perform experiments to determine whether slathering oil on food helps preserve it. Then we can add those experiments to our natural histories and perhaps assign a greater degree of certainty to some related instances. The enhanced natural history produced thereby can then help us refine, clarify, or upgrade our original hypothesis about aging, so that, with the improved hypothesis, we can improve our natural histories even more, and so on in a continuing spiral.

Going back to the instance that sounds can be produced without air, we can see that Bacon's certainty probably owes something to some axioms that he accepts. For example, he holds that flame and air are hostile to each other. (He thinks that the pyramidal shape of a flame is the result of the air pushing in on the flame as it gets further from its fuel source down below.⁹⁰) Given that view—it is difficult to say how much certainty Bacon assigns to it, but the point here is just to illustrate the general method—Bacon has an additional reason to put some weight on the instance where he strikes the tongs within a flame. Since sounds can be created within a flame, and flame and air are hostile, it would be surprising if the sound created within a flame somehow owed its existence to the air. Notice again that Bacon intends for his natural histories to be intertwined with his speculations about causes. The more one becomes certain about causes, the more one is entitled to use them in guiding the construction of a natural history.

Closely related to the art of indication are the nine aids to the intellect outlined by Bacon in II. 21 of the *Novum organum*, especially the prerogative instances. (Some of these aids to the intellect play a role in self-correction as well.) Among the aids that are relevant to the enhancement of natural history are the prerogative instances and the supports to induction.

⁹⁰N.O. II. 36, I2^v.

The discussion of the twenty-seven prerogative instances takes up the second half of Book II of the *Novum Organum*. These are instances which are of particular importance in either the construction or the analysis of natural history, so we should use the art of indication to seek them out or to upgrade their epistemic status. I will discuss the prerogative instances in further detail in Chapter 5 since they are more properly associated with the fourth part of the *Instauratio* than with the third.

As for supports to induction, it takes some detective work to figure out just what they are. Bacon mentions them twice in the course of his discussion of the prerogative instances that aid the senses, once in connection with supplementary instances⁹¹ and once in connection with the limits of dissection.⁹² Supplementary instances are usually employed when proper instances are unavailable. When there is nothing available that completely lacks heat, for instance, one can use something with a very low degree of heat as a substitute. Bacon associates supports to induction with the use of these supplementary instances in contexts where proper instances are already available; i.e., even if one already has instances in one's natural history that lack heat entirely, one can work towards adding to the certainty of a provisional interpretation about heat by seeking out supplementary instances.

Instances of dissection are instances which make evident the smallness of the parts of nature. These include cases in which actions in a medium do not interfere with one another. To these Bacon subjoins limits of dissection, which are cases in which actions of the same kind do interfere with one another (e.g., a louder sound drowns out a quieter one). What do these limits have to do with supports to induction? One can only speculate here, but I think Bacon has something like the following in mind: Sometimes we fail to notice instances of a nature because they are drowned out. By noticing the limits of dissection, we can try to add these instances to our natural history. This is what Galileo does, for instance, when he argues that the sunspots, though they appear dark, are actually quite bright. If one were developing a table in which the nature of light is present, one could, thanks to Galileo's efforts and the limits of dissection, include sunspots in

⁹¹*N.O.* II. 42.

⁹²*N.O.* II. 43.

the table, thereby enhancing our natural history with new instances that can help add to the certainty of a provisional interpretation, as we try to progress towards something less provisional.⁹³

4.5.3 Self-Correction

More of a problem than enhancement, from the standpoint of a defense of certainty, is what to make of the process of self-correction, where natural historical claims are either downgraded or rejected entirely. In particular, it might appear to be a problem if there are ever cases where claims that were once thought certain end up being rejected as false. Call this the problem of error: how can we be epistemically certain of anything if our psychological certainty sometimes turns out to be misplaced?

Bacon tackles this problem in a passage from the *Novum organum*:

People will no doubt think when they have read over this same history of ours and the tables of discovery, that there is something in those very experiments which is less than certain or downright wrong, and because of that they may imagine that my discoveries rest on false and doubtful foundations and principles. But this is of no account, for such things necessarily occur when we are starting off. For it is like in writing or printing where if one letter or other be misplaced or wrongly set, it does not generally get in the way of legibility very much, for such errors are easily put right by the context. In the same way, men should think that many experiments in the natural history may be unworthy of credence or reception which will be easily expunged and rejected soon after by the causes and axioms we have discovered. But it is nevertheless true that if the errors in natural history and the experiments are considerable, recurrent and repeated, no stroke of wit or art can correct or put things right.⁹⁴

Bacon's first response to the problem of error is that it is not in fact a problem because it is unavoidable, "for such things necessarily occur when we are

⁹³Graham Rees, in his introduction to the *Novum organum*, suggests a somewhat different account of Supports to Induction, saying that they "may have been to designed to deal with, *inter alia*, ways of getting to grips with difficult data, and particularly with spirits and immaterial phenomena." Bacon, *The Instauration magna Part II: Novum organum and Associated Texts*: xciii.

⁹⁴*N.O.* I. 118.

starting off.” This is a limited response. It is true that it is pointless to rage against something that can’t be changed, but if Bacon said no more, then one might take him to be saying that we should be content to be skeptics since it is impossible to eliminate all of the false and doubtful claims from our natural histories. And that is not Bacon’s view.

Bacon’s second point is more important, then. Errors may not be avoidable at first, but they are correctable and are not ultimately a serious obstacle to certainty. But Bacon is being a little quick here. How can causes and axioms discovered on the basis of false and doubtful foundations be relied on to correct those foundations?

The answer is related to his printing metaphor. Minor typos in a text can be corrected based on the context, but as the number of errors increases, it becomes more and more difficult to figure out the intention, and if the number of errors is sufficiently great, it might be impossible to do so. Analogously, if there are isolated errors in one’s natural history, or at least if they are confined to certain types of cases, it may still be the case that there are enough instances to overwhelmingly suggest the truth of some axiom. If that axiom conflicts with a set of cases that is somehow delimited, then one can reexamine those instances in the light of more advanced knowledge, techniques, and instruments. On the other hand, if there are a large number of errors scattered throughout one’s natural histories, then they might overwhelmingly suggest the truth of a false axiom. In that case, Bacon holds, self-correction is impossible by means of “wit or art,” leaving only luck.

It is easy to illustrate the general idea. In his *Historiae vitae et mortis*, Bacon records the lengths of the lives of various Biblical figures, expressing no doubt that the reports might be inaccurate. The Bible is as trustworthy a source as can be. Initially men lived for hundreds of years, then that was cut in half after the flood, and Moses lived only 120 years. Do these errors impede Bacon from ever discovering with certainty the causes of aging, given that these are among the instances he will draw on to discover those causes? Not according to Bacon. If these instances were overwhelmingly at odds with the causes of aging suggested by other phenomena, then he could be persuaded to reexamine them and to consider

figurative interpretations of the relevant Biblical passages.

Bacon mentions the most radical sort of self-correction, where causes discovered with certainty allow one to reject a handful of instances as certainly false. But presumably, self-correction can also work more gradually. Speculations, anticipations, and first vintages might progressively cause one to assign less and less certainty to an instance. These downgrades should make it still easier to investigate causes and axioms without being distracted by erroneous instances.

In addition, one of the aforementioned aids to the intellect seems to have a role to play in self-correction. “Rectifications of Induction” are mentioned only twice by name throughout the *Novum organum*, but they probably involve the use of scientific instrumentation to help us figure out whether any of our instances are mistakes caused by the deceptions of the senses, as when we use a thermometer to justify the removal of “spicy food” from our list of instances where heat is present.

4.6 Objections and Replies

This chapter has explored some controversial territory. While I cannot anticipate all possible objections, it seems to me that two kinds of objections are worth responding to. In 4.6.1, I would like to respond to worries about unifying the method of discovery with the hierarchy of justification. Recall the four theses I attributed to Bacon:

- B-1 The act of discovering any notion, fact, or axiom justifies the acceptance of that item.
- B-2 Justification is the tracing of a possible path of discovery.
- B-3 The very same method ought to govern both discovery and justification.
- B-4 At least in some cases, the best justification (if more than one justification is possible) is the one that traces an actual historical path of discovery.

As I mentioned earlier, my main purpose in unifying discovery and justification was to assist in reading and interpreting Bacon, not to defend his views about

this particular issue. Still, this is a dissertation on Bacon's views on justification, and it is important that I have not illegitimately ignored an important discovery-justification distinction in order to make Bacon's account of justification look more plausible than it is. In 4.6.2, I would like to consider some objections to Bacon's account of enhancement and self-correction.

4.6.1 Problem Cases for Discovery-Justification Unity

Given a method with the features just discussed, there are some reasons for thinking that discovery and justification do come apart in ways that violate B-2 and B-3 (but not, as far as I can tell, B-1). My scaffolding metaphor strongly suggests this. When we are engaged in the process of discovery, we must use scaffolding. But isn't the goal to reach a stage where we can remove the scaffolding? Here are three apparently problematic kinds of cases:

The Directly Verifiable Particulars Case This case occurs when there are entries in our natural history that could not have been discovered without first discovering either other entries in the natural history or axioms about causes. But it seems unusual to say that those new natural historical entries require those heuristically prior items for their justification. After all, a natural history concerns particulars and should be verifiable by looking to the particulars in question.

An example of the first kind might be the discovery that the moon's rays are not hot. Here is a narrative illustrating a possible path by which this discovery might be made: "I know that the Sun is hot. And look, a magnifying glass concentrates the rays of the sun, making its heat even more apparent. If I could translate this experiment over to the moon, I could discover whether the moon's rays are hot. And look again, a magnifying glass produces no heat when applied to the moon's rays, thereby suggesting to me that its rays are not hot." The seeming problem for Bacon is that every step in this narrative except for the last one seems irrelevant to the justification of the claim that the moon's rays are not hot. That claim can be justified just by performing the final experiment; one did not have to proceed by first starting with the Sun and translating the experiment from the

one domain to the other.

So here we have a seeming counterexample at least to B-3, since it seems one did not have to follow Bacon's method of discovery (which employs literate experience in this case) in order to arrive at the final justification. Whether it is a plausible counterexample to B-2 depends on whether one thinks starting with the last step is really a possible path of discovery. As for B-1, I can see nothing about this example that would contradict it.

A second kind of example of the Directly Verifiable Particulars case has a similar structure but employs the Interpretation of Nature instead of literate experience. Suppose that we are wondering what the tides are like in a part of the world we have never seen and have not received reports from. We might discover what the tides are like there by first investigating what causes tides and then applying our causal knowledge to the particular case. That is at least a possible path of discovery. But if we wanted to, we could justify the claim about the tides in that particular place by sailing over there and checking with our own eyes.

This example does not seem to plausibly contradict B-1 or B-2. With respect to B-1, making the discovery via the knowledge of the cause of tides seems to provide a justification as well, even if another justification is possible through direct observation. And in accordance with B-2, the justification through direct observation seems to be a possible path of discovery. But it does seem possible that this example contradicts B-3. Perhaps our investigation of causes is sometimes a good way of making discoveries in natural history, but when we start to think about justifying those discoveries, we should when possible confirm them through direct observation.

The Fill in the Gaps Later Case Suppose there are gaps in our natural history while we were engaged in the process of discovery. At some later time, we fill in those gaps, and at that time our inductive knowledge turns out to be justified by the entries that fill in those gaps. So don't we make our inductive discoveries without relying on natural historical entries that, it turns out, are later needed to justify the claims we already discovered?

Baconian First Vintages offer good examples here. Suppose Bacon was right

in the *Novum organum* when he hypothesized on the basis of his schematic natural history that heat was a kind of motion. In that case, he made his discovery on the basis of an incomplete natural history. To justify that hypothesis, though, he would have to appeal to less flawed and more complete version of the history.

Again, I am not sure that B-1 is very plausibly contradicted by this example. The schematic natural history that enables the discovery might not be a perfect justification of the hypothesis, but it does provide some justification. But B-2 and B-3 do seem to be contradicted. With respect to B-2, the final justification (on the basis of a complete and certain natural history) was not, it seems, a possible path of discovery. There is no way one could have finished a complete and certain natural history concerning heat without first having the hypothesis about heat and using it to further improve the history. And with respect to B-3, it seems that there are principles of method applying to the justification which are not needed simply for making the discovery. For example, the method of justification might include rules about when the natural history is sufficiently complete and certain, whereas such rules are unnecessary just to make the discovery.

The Correct the Errors Later Case In this case, there are errors in our natural history while we are engaged in the process of discovery. At some later time, the process of self-correction removes those errors. At that later time, surely our justification for any ideas that originated from those errors does not include the errors themselves. In short, errors might have been necessary in the process of discovery, but one would think that they should be omitted from a justification.

Suppose, for the sake of an example, that Bacon's trust in Scripture was justified, so that he was justified in believing its reports about the lifespans of the first humans. Now suppose that Bacon later made a discovery about the cause of aging and even first thought of his hypothesis thanks in part to those scriptural reports. But after more careful study, it turns out that his hypothesis is incompatible with the literal reading of the scriptural reports and he offers a figurative reading instead. What would Bacon say if at this point you asked him to justify his hypothesis about aging? Would he include his initial error? Seemingly not.

B-1 is again unaffected by this example, as long as we recognize that justification can be defeasible. At no stage in the narrative is there a discovery made that is not accompanied at least by a defeasible justification. However, B-2 and B-3 are both seemingly threatened. B-2 is threatened as long as there are some cases where errors are unavoidable; if there are such cases, and if justifications leave those errors out, then justifications sometimes trace paths that are not possible paths of discovery. As for B-3, how could the method of discovery and justification be the same, when the method of discovery follows a path that allows for errors and the method of justification calls for those errors to be removed?

Replies to the Three Cases Although these cases are all allowed and even suggested by some of Bacon's methodological ideas, the cases can be interpreted in a way that is compatible with his ideas about discovery and justification. As we saw, B-1 was not threatened by any of the cases. So it remains to show how B-2 and B-3 can be preserved.

Reconciling B-2 with the Directly Verifiable Particulars case requires clarifying what it means for a path of discovery to be a possible one. Surely there are some cases where a justification can be given today that does not trace a path of discovery that would have been possible in the ancient world. We can justify the view that the Earth is round by pointing to a NASA photo, but that was not a possible path of discovery for the ancients. But this is not a problem for B-2, as I am understanding it, because a path of discovery that makes use of the NASA photo *is* possible today. B-2 means that justification traces a path of discovery that is possible at the time the justification is being given and for the person whose belief is being justified. In terms of Figure 4.1, items such as photographs are particular instances in a natural history, and once they become such, they can be used both to discover and to justify axioms.

It is also important to note that the original interpretation of the case overestimates the powers of direct observation. In the example with the magnifying glass and the moon's rays, the objections to B-2 and B-3 rely on the assumption that one could justify the instance about the moon's rays through direct observation. This assumption is mistaken. One needs some reason for thinking that

this new experiment is informative about the heat of the moon's rays. The prior experiment with the Sun is a crucial part of the justification for interpreting the new experiment in the right way. It is an important point to bear in mind, when interpreting Figure 4.1, that justification, for Bacon, includes the whole messy process that generates an idea, including a great number of repeated ascents and descents on the ladder of enhancement and self-correction. If we fail to use higher level items to interpret our natural histories, then they will lose *both* heuristic and justificatory power.

The same could be said in the example concerning the tides. Even if one traveled to the place in question and observed the tides there firsthand, some understanding of what causes the tides remains necessary in justifying the belief that the tides will maintain a regular pattern in this new place. Therefore, this case fails to show that Baconian induction calls for one method of making natural historical discoveries and a different method of justifying the entries. B-3 is preserved.

The reply to the first case helps in responding to the Fill in the Gaps Later case as well. It is true that one might initially have a hypothesis about what heat is before the natural history concerning heat includes all the entries that are necessary to fully justify that hypothesis. But that fuller justification depends on the newly added natural historical instances, and those instances could not have been justified without the initial hypothesis having been justified. So again, in following Bacon's method of discovery, we follow the very steps that we need to follow in order to provide justifications.

Again, the Baconian justification of an axiom does not just make reference to a natural history in its finished state. It has to make reference to the whole process of inquiry through which that finished state of the natural history is justified. B-2 is therefore preserved. Justification still traces a possible path of discovery.

B-3 is preserved as well. The method of discovery, just like the method of justification, needs to provide guidance not just in choosing hypotheses but in refining those hypotheses and turning them into well-founded axioms. The Baconian method of discovery does not stop when First Vintages are created; it is a method for discovering axioms with certainty and calls for a single method to be

followed until that point is reached, at which point one should have a conclusive justification of the axiom as a matter of course.

What about the Correct the Errors Later case? The key here is to distinguish between errors that were justified at the time they were put forth and those that were not. If they were initially justified, then one would be reasoning in an unjustified way if one just omitted those errors from one's justification. One has to earn the epistemic right to omit those errors by explaining why, despite their initial justification, they should be rejected. So again, the steps of one's justification must follow the proper method of discovery. But if the errors were not initially justified, then it is true that they can be omitted from later attempts at justification, but they have could have been eliminated from the process of discovery too.

4.6.2 Two More Problems for Revision Mechanisms

I want to clarify the nature of enhancement and self-correction by responding to two reasonable concerns that one might have.

The first worry pertains to whether top-down reasoning should be regarded by the foundationalist as question-begging. With respect to enhancement, one might worry that the view that higher level items confer additional degrees of justification on lower level items leads to problems with circularity. For example, it would clearly involve viciously circular reasoning to use Belief A (which is, let us say, 80% justified) to justify Belief B (such that it is 70% justified), and then to use Belief B to add to the initial degree of certainty in Belief A. Similarly, with respect to self-correction, one might worry that it begs the question to use higher level items to undermine the justification offered for lower level items. For example, we would not want to use Belief C (which is 80% justified) to justify Belief D (such that it is 70% justified), and then to use Belief D to rebut Belief C, on which its very justification depended. It is important to point out that this sort of thing is not what Bacon's method involves.

Here is a more viable schematic of top-down enhancement. Let us say that Beliefs A1, A2, and A3 all offer independent lines of support for Belief B. Now suppose that B offers support for A1. Since B has support not only from A1

but also, independently, from A2 and A3, it is possible for B to confer additional justification on A1 beyond what it had initially. This is because some of the support offered for B did not come from A1 or from any other beliefs which themselves derived their support from A1.

And here is a more viable schematic of top-down self-correction. Beliefs C1, C2, and C3 all offer independent lines of support for Belief D. But it then turns out that D is incompatible with Belief C4. If C1, C2, and C3 are all strongly justified, then it is not obviously problematic to use them to rebut C4 (via their support for D).

A second problem. Bacon says that we can count on self-correction only if our errors are delimited. If we merely have to assume that our errors are delimited, then this would be a weakness in Bacon's account.

But Bacon offers some reasons for thinking that our errors are not too widespread to undermine the self-corrective process, if we look to his diagnosis of the causes of error, which is a central theme of the first book of the *Novum organum*. He lists a number kinds of causes in Book One: the idols;⁹⁵ the fact that there had been only three periods of learning in history;⁹⁶ the relative lack of attention paid to natural philosophy;⁹⁷ the idea that natural philosophy should be subservient to something else;⁹⁸ the pursuit of knowledge for goals other than conquering nature for the betterment of the human condition;⁹⁹ the lack of a sound method;¹⁰⁰ reverence for antiquity, authorities, and popular opinions;¹⁰¹ a failure to imagine just how much progress ought to be possible;¹⁰² opposition from religious zealots;¹⁰³ poorly conceived educational institutions that emphasize dogma over discovery;¹⁰⁴ poor political institutions that fail to incentivize scientific progress;¹⁰⁵

⁹⁵These are discussed in I. 38-68 and then identified as the subtlest of these causes of error in I. 115.

⁹⁶*N.O.* I. 78.

⁹⁷*N.O.* I. 79.

⁹⁸*N.O.* I. 80.

⁹⁹*N.O.* I. 81.

¹⁰⁰*N.O.* I. 82.

¹⁰¹*N.O.* I. 85.

¹⁰²*N.O.* I. 88.

¹⁰³*N.O.* I. 89.

¹⁰⁴*N.O.* I. 90.

¹⁰⁵*N.O.* I. 91.

and a lack of confidence that humanity is up to the job (which last cause Bacon attempts to address with a section of Book One listing some reasons for hope).¹⁰⁶ Bacon's position is that because just about all of the errors committed in the history of natural philosophy are the product of these causes, and because we should expect the Baconian project to combat these causes effectively, we should not expect widespread errors to be an issue any longer, provided he has successfully identified the most significant causes of error. But if we don't guard against the idols and the other causes of errors, then the errors in natural history might be too pervasive to correct: "radical errors in the first digestion of the mind are not to be put right afterwards by first rate functions and remedies."¹⁰⁷

This position is a sign of the importance of Bacon's foundationalism and why, despite its self-correcting character, it is importantly different, both in theory and in practice, from anti-foundationalist or coherentist theories.

4.7 Conclusion

I have offered an interpretation of Bacon's natural historical method as a moderate foundationalist one. His goal is a natural history, like that described in the *Parasceve*, which is reliable enough to be treated as a body of factual information to which the account of induction in the next chapter can be applied. However, as we have seen, the road toward the justification of that final, pure natural history is long and complex. It begins with first-level notions justified directly by sense-perception, proceeds to basic beliefs (which amount to predications that are justified by the first-level notions in conjunction with sense-perception), and then, on a first iteration, proceeds to justify more and more abstract notions and beliefs. Top-down enhancement and self-correction mechanisms then play an important role in revising and adding to the certainty of everything prior. On each subsequent iteration, there is the potential for various instances in the natural histories to become more certain. Furthermore, Bacon offers a generative account of justification, such that natural history will always depend epistemically on sup-

¹⁰⁶*N.O.* I. 92

¹⁰⁷*N.O.* I. 30.

port relations to items *both* above and below it. Natural history should eventually be written in a pure form, in preparation for the focus on a terminal inductive stage of the method, but it will always require a possible path of discovery for its justification—and that possible path is unavoidably messy.

I have shown that, by these means, natural history is designed to be capable of progressively increasing degrees of certainty. Note, though, that enhancement and self-correction depend on the Interpretation of Nature, i.e., on Baconian induction. Therefore, the defense of Bacon in this chapter cannot be complete until we examine Bacon's resources for defending the certainty of induction. That is the task for the next chapter.

4.8 Acknowledgements

This chapter, in part, significantly reproduces material that has been published in *The Journal of Early Modern Studies* (Volume 3, Issue 1) in the form of an article titled "Is Baconian Natural History Theory-Laden?" The dissertation author is the sole author of that article. I would, however, like to acknowledge the helpful comments of Donald Rutherford as well as two anonymous reviewers. Their feedback on that article resulted in many improvements that made their way into this chapter.

Chapter 5

Induction

I have shown that Bacon aims to offer a method by which natural history can be discovered and justified to progressively increasing degrees of certainty. But natural history, for Bacon, is not an end in itself. Its purpose is to provide the data for the method of induction, the goal of which is the knowledge of causes, especially formal causes. Since I have discussed the processes of developing, enhancing, and correcting a natural history, the next question is how induction (i.e., the interpretation of nature) works and whether we can be certain of the conclusions that we reach by means of it. I emphasize that this division between constructing a natural history and reasoning inductively on the basis of that natural history is somewhat artificial. In reality, as I hope the previous chapter made clear, one has to shuffle back and forth between these two different parts of the *Instauratio*. The more complete and reliable a natural history becomes, the better a foundation it can be for the interpretation of nature; and as one's knowledge of causes thereby expands, the natural history can be still further improved.

That said, at any given point in the development and justification of a natural history, whether that natural history is still incomplete and uncertain, or whether it is copious and certain, there is a separate inductive step that we can focus on in abstraction from the natural historical work that precedes and follows it. This chapter aims to show why Bacon thinks that the conclusions warranted by his method of induction can be just as certain as the natural history on which they are based, assuming that all the requisite instances are present. The

relevant conception of “certainty” is, as always, justification beyond a reasonable doubt, so the thesis I will defend amounts to the claim that he has resources in his methodology which support him in denying that reasonable grounds for doubt must crop up just because the method is inductive. Indeed, some of *usual* reasons for doubt that are put forward as criticisms of Bacon arise partly as a result of straw man portrayals of his method of induction.

Bacon’s view is that doubtful natural histories allow for doubtful inductive conclusions, that probable natural histories allow for probable inductive conclusions, and that certain natural histories allow for certain inductive conclusions. There is one caveat. I say that histories *allow for* inductive conclusions that are just as certain because the completeness of a natural history is an independent factor that also affects the certainty of the inductive conclusions. An absolutely certain natural history about heat that includes only the instance that the sun is hot will not allow you to draw any certain or even probable conclusions about the formal cause of heat. This is not to say that one will ever be warranted in drawing erroneous conclusions on the basis of an incomplete natural history, but it is to say that to avoid errors when reasoning inductively on the basis of an incomplete natural history, one must own up to the limited certainty of the conclusions, even if the natural historical premises were certain. The way to avoid errors in such a case, in other words, is to suspend assent.

This chapter focuses on the special case of inductive reasoning where the natural history on which it is based is both certain and sufficiently complete since that is the case that will allow for the possibility of certainty about formal causes. But I take it that my conclusions could be extended more widely. Table 5.1 situates the case that I am focusing on (at the bottom right of the table) among a range of some other possible cases and some possible classifications of the epistemic status of the inductive conclusions in each case. The left column describes different degrees of completeness of a natural history, while the top row describes the degree of certainty that generally characterizes the instances in that history. The body of the table shows how the degree of certainty that results for our claims about formal causes is a function of both of these factors. I have adopted Bacon’s far-from-rigid

Table 5.1: The Degree of Certainty of Axioms as a Function of the Completeness and Degree of Certainty of a Natural History

	Doubtful History	Probable History	Certain History
Radically Incomplete	Anticipations of Nature (worse)	Anticipations of Nature (better)	Anticipations of Nature (best)
In Progress	Speculations (worse)	First Vintages (worse)	First Vintages (better)
Sufficiently Complete	Speculations (better)	First Vintages (better)	Conclusively Justified Axioms

terminology, which allows for some speculations to be more certain than others, for example. I therefore use the labels “worse,” “better,” and “best” to facilitate finer-grained intra-category comparisons.¹ I also note that it may be impossible to perform some inter-category comparisons; it is not clear, for example, whether the best anticipations of nature are more or less certain than the better speculations. Because the degree of certainty and the completeness of a history both increase in tandem, though, the bolded categories are the most important.²

Since philosophers of science generally agree that induction unavoidably carries some risk of deriving false conclusions from true premises—that, in contrast to deduction, it is not truth-preserving—I of course will need to say a great deal to spell out the resources Bacon can draw on to resist this view. The typical answer given, which I will dispute, is that he regards his own method of so-called eliminative induction as superior to the usual method of induction by simple enumeration and that the riskiness usually associated with induction belongs (in Bacon’s mind) only to the latter. Eliminative induction is then typically

¹It is not clear whether a First Vintage based on a probable but complete history would be better or worse than a First Vintage based on a certain history that still requires more instances.

²The purpose of this table is primarily to emphasize that my discussion in this chapter deals with a special case, so I do not think it is worth dwelling on it. However, some documentation of where Bacon employs these terms in roughly these ways might be helpful. The view that the best we can do with radically incomplete natural histories is to derive useful anticipations of nature is strongly suggested by the *Prodromi sive Anticipationes Philosophiae Secundae* in Bacon, *The Instauration magna: Last Writings*. Unfortunately, a number of different Latin terms employed by Bacon are sometimes translated as “speculations.” *Commentationes*, in the preface to the *Historia naturalis*, do not seem to fall very short of First Vintages, but that is the Latin term to which I mean to refer. Bacon, *The Instauration magna: Part III: Historia naturalis*: C5^r 7. (The term is also regularly used as a heading in the Latin natural histories.) First Vintages are equated with provisional interpretations in *N.O.* II. 18.

characterized as a method that begins with a finite list of possible causes and experimentally falsifies all but one of those possibilities. Schematically, it follows the form of a disjunctive syllogism:

(5.1)

- (1) A type of phenomenon P is caused by either A, B, C, or D.
- (2) Neither A, B, nor C are the cause (by observation, e.g., an instance is found where A is present but P isn't).

∴ (3) D is the cause of P (by disjunctive syllogism).

It is sometimes added that this process of elimination is only the first step in Bacon's method and that he has a hodgepodge of techniques (the twenty-seven prerogative instances, in addition perhaps to a pragmatic check that the conclusion brings with it increased power over the world) that purport to compensate for the shortcomings of this method.

This interpretation of Bacon is inadequate both textually and philosophically, and given that this is how Bacon is widely interpreted, it is no surprise that his aspirations to certainty about causes are swiftly dismissed. Eliminative induction of this sort carries with it quite a bit of inductive risk, and this risk cannot be ameliorated by means of some hand-waving reference to subsequent steps in the method. I will focus on three sources of risk (while considering a few more along the way), two related to underdetermination and one related to the issue of extrapolation.

One of the main sources of risk is the problem of underdetermination, which says that more than one theory is typically compatible with the evidence (or as applied to Bacon that more than one account of a formal cause would typically be compatible with the instances in a natural history). Eliminative induction leads to this problem for two reasons. First, there is a problem with the first premise. How do we know that we have listed all of the possible alternative explanations for

the phenomenon in question? There was a day when nobody would have dreamed of explaining the phenomenon of light by saying that photons are wave-particles, yet today that is the accepted explanation. Second, there is a problem with the second premise. A natural historical instance can falsify an account of a formal cause only if auxiliary assumptions are added. But then it is possible to reject one of the auxiliary assumptions rather than the account of the formal cause.

Another area for concern is the extrapolation implicit in the reference to P as a single type of phenomenon. After all, Bacon seeks causal explanations of phenomena (such as qualities) in general, not just of single instances. He wants to know the cause of heat, not the cause of *this* instance of heat. But why not think that sometimes a phenomenon like heat or light has one cause, and sometimes it has another cause? Suppose we learn something about the phenomenon of digestion by studying a population of rats. Even if we could dodge issues related to underdetermination and find an account of a formal cause that was not falsified, it is not clear that we would know the formal cause of digestion in general because what we call “digestion” may not be a single type of phenomenon. Oftentimes we call two things by the same name even though they turn out not to be the same phenomenon.

Although Bacon employs a partly eliminative method early in the process of induction, we need to focus much more closely on the subsequent usage of the so-called prerogative instances to see that Bacon has compelling ways of dealing with these reasons for doubt.

This chapter will be structured as follows. In 5.1, I will discuss some of the most important interpretations and assessments of Baconian induction, explaining as I go why the existing accounts are both philosophically weak and textually inadequate. Then in 5.2 I will take a closer look at Bacon’s theory of induction and argue that the standard reading of Bacon as a proponent of eliminative induction is misleading. There is indeed an eliminative stage in his method, but the purpose of this stage is not to attempt to rule out every possible explanation for a phenomenon but one. I will divide my account of Baconian induction into three stages: (5.2.1) the destructive stage, which (although it technically precedes the interpretation of

nature as a sort of propaedeutic) is worth examining in this chapter because of the response it offers to a mild form of the problem of the criterion; (5.2.2) the stage where the method of elimination predominates, which allows one to form a First Vintage or hypothesis concerning a formal cause; and (5.2.3) the stage where the use of the prerogative instances predominates, which often culminates in the discovery of crucial instances that conclusively establish an axiom. In 5.3, I will take a closer look at crucial instances and reply to the standard Duhemian objections to them which stem from the problem of underdetermination.

5.1 Rival Interpretations and Assessments

It will be useful to begin with a survey of some of the more noteworthy attempts to explain Bacon's method of induction. One of my aims here is to show the prominence of the interpretation of Bacon as a proponent of eliminative induction and how that view leads to grounds for doubt in the results of induction which my own interpretation will then be able to assuage. There will also be a few other points of contrast between my own interpretation and existing interpretations that I will need to emphasize. The alternative interpretations examined here include eliminative interpretations by Gaukroger (5.1.1) and Jardine (5.1.2), a non-eliminative interpretation by Urbach (5.1.3), and an important new non-eliminative interpretation by McCaskey (5.1.4).

5.1.1 Gaukroger

As Gaukroger observes and as I have already discussed in Chapter 2, the central goal of Baconian induction is the discovery of the formal causes of simple natures. Again, simple natures are qualities such as "hot" and "white," and the reason we should prioritize their study is that they are like letters in the alphabet in comparison to books. The world, like a book, can contain an infinite amount of variety, yet all books are constructed out of a limited number of letters, just as the vastly complex world contains some limited number of qualities through which we can come to understand the substances that have those qualities. The formal

cause of a simple nature is, in Gaukroger's view, the microscopic structure that is necessary and sufficient for the presence of the macroscopic quality in question.³ I think this is too narrow a conception of the Baconian formal cause; it ignores the fact that Bacon is perfectly willing to talk about formal causes of non-bodily natures and holds that his method is applicable to every area of study, including those outside of natural philosophy such as ethics, politics, and logic. But leave this objection aside for now. My own account of what formal causes are can be found in Chapter 2.

Much of Gaukroger's account is accurate. The prerequisite for using induction to discover these formal causes is the completion of a copious and reliable natural history concerning the simple nature in question, a natural history of heat if one is investigating the formal cause of heat, a natural history of whiteness if one is investigating the formal cause of whiteness, and so on. These natural histories contain instances of phenomena arranged in three tables. The first contains instances where the phenomenon is present, while the second contains instances where the phenomenon is absent. Since this second category would otherwise be infinite, the table includes only those instances that resemble an instance where the phenomenon is present. For example, if an instance of presence is the sun's rays, an instance of absence might be the moon's rays. Gaukroger notes that the table of related absences has the added function of directing the investigator towards experiments that might disclose instances of absence that are not yet known. The strategy Bacon employs is to try to vary items in the tables of presence in order to see if he can experimentally produce something similar but lacking the nature in question. (This is one variety of what I covered in Chapter 4 under the heading of *literate experience*. See especially the entry on "variation" in Table 4.1 on p. 128.)

³Gaukroger makes a related claim that Baconian explanations are effectively restricted to efficient causes. This claim is bizarre. Efficient causes of heat include rubbing, lightning, and flame. Bacon does not limit the investigation to causes such as these, and indeed his requirement for "liberty" in a rule, discussed in Chapter 2, is intended in part to push us beyond efficient causes such as these. Perhaps Gaukroger simply means to assert that it is problematic that Bacon assumes that the necessary and sufficient conditions for a simple nature will always involve the particulate structure of bodies. But since this is certainly not an *a priori* assumption, I don't see the problem. In applying Bacon's method one might eventually discover that the explanations of the qualities of bodies invariably turn out to refer to their smallest parts. Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy*: p. 149.

Finally, the third table includes instances which exhibit the phenomenon or nature in question as it varies in degree.

After these natural histories are composed, the process of induction can begin. Gaukroger sees it as a two-stage process. In the first stage, he claims, Bacon first uses eliminative induction and then the prerogative instances to ascend from the natural history to hypotheses concerning formal causes. Then in the second stage he confirms or disconfirms those hypotheses by deriving particular results from them. Gaukroger argues that the eliminative aspect of the first stage is Bacon's most original innovation, but Gaukroger has a rather negative assessment of it. The prerogative instances get a cursory treatment from him in comparison, and he seems oddly untroubled by his account of the second, justificatory stage.

I will get to that second stage and its problems in a moment. Taking his account of the method of induction in order, though, let us begin with the method of elimination. Gaukroger holds that eliminative induction, although not the only part of Bacon's method of induction, is the part that Bacon intends to do the heavy lifting. Such an interpretation emphasizes passages such as this one, which compares induction to the alchemical process of distillation:

As far as the discovery of forms goes, the first job of true Induction is to Reject or Exclude individual natures which we cannot find in any instance where the nature under investigation is present, but can find in any instance where the given nature is absent, or find growing in any instance when the given nature wanes, or waning when the given nature grows. Then, once we have performed Rejection and Exclusion in the right ways, the residue left, after all volatile opinions have been driven off as fumes, will be a form affirmative, solid, and both true and well-defined.⁴

"The procedure he elaborates," Gaukroger comments, "eliminative induction, is one in which various possibly contributory factors are isolated and examined in turn, to see whether they do in fact make a contribution to the effect."⁵ The investigator searches for necessary and sufficient conditions for the phenomenon, and he can eliminate those natures which might be thought candidates for necessary

⁴*N.O.* II. 16.

⁵Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy*: p. 139.

or sufficient conditions by finding natures that are not always present when the phenomenon is present, or not always absent when the phenomenon is absent, or that do not vary in proportion to the variation of the phenomenon. The idea, according to Gaukroger, is that one will eventually be left with just those conditions that are necessary and sufficient and thus be left with the formal cause, or one will at least come close to that and thereby be able to come up with the First Vintage (i.e., with a hypothesis concerning a formal cause).

Now let us consider the assessment of Bacon which this account leads Gaukroger to offer. The assessment is overwhelmingly negative. Two of his objections to Bacon are most relevant for my purposes. First, he argues that eliminative induction fails to converge on a single explanation of a phenomenon. “One might admit some degree of convergence, but there is nothing like convergence to a point.”⁶ Now, this objection is a little odd, given that Gaukroger has already stated that the eliminative stage of the method may only lead to a hypothesis and that Bacon believes there is more work still to be done. It is therefore unclear why the eliminative stage needs to converge to a point. Still, we can see that Gaukroger is worried about the problem of underdetermination here, insofar as it can arise from the failure to list all possible explanations.

Next Gaukroger raises a good point. Even if we concede that eliminative induction sometimes allows us to converge on an explanation, nevertheless “the real skill, and what really drives the whole process, comes in identifying the possible explanations in the first place.”⁷ Quite true. But Gaukroger seems to believe that Bacon has nothing substantial to say about how this identification is to be accomplished. I will argue in my own account below that some of the prerogative instances play a role in identifying the possible explanations.⁸

Let me indicate here a reason for being skeptical of Gaukroger’s account thus far. Note that his examples (taken from Bacon) do not follow a strictly eliminative procedure. Gaukroger himself notes that Bacon, in presenting his example concerning heat, identifies the fact that heat is a species within the genus

⁶Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy*: p. 150.

⁷Ibid.: p. 151.

⁸Migratory instances and shining instances are the most relevant here. See p. 190ff.

of motion by focusing on instances where the violence of the motion is especially obvious. It is important, although Gaukroger does not mention the fact, that these instances are examples of what Bacon calls shining instances, which are among the prerogative instances. Shining instances, according to Bacon, are especially useful in discovering the differentiae in the specification of the formal cause, so it is somewhat puzzling that Bacon seems to use these shining instances at first to discover the genus of heat rather than the differentiae. I will return to this role of shining instances in 5.2.2 (on p. 186). In any case, Gaukroger seems not to notice the tension between the use of shining instances to hone in on the genus of heat and the general account of the method that Gaukroger has just presented. If Bacon's method at this stage is just an eliminative one, then he ought to discover that the genus of heat is motion by ruling out every other possible genus. And yet that is not what he does.

Gaukroger could try resolve this tension by insisting that the use of shining instances is merely a heuristic aid and that eventually Bacon will have to complete the eliminative procedure. Yet Gaukroger himself treats eliminative induction as a method of discovery and suggests that the justificatory work comes later, in the second stage of the method, where a pragmatic check must be employed. So why would it be necessary to complete the eliminative procedure as long as the work of discovery has been completed? And even if Gaukroger can respond to this particular worry about shining instances, there is a sign here of something more deeply amiss, a sign that the prerogative instances play a more fundamental role than Gaukroger recognizes and that he has erected a straw man against Bacon.

After eliminative induction allows one to form a hypothesis, the next step, according to Gaukroger, is to apply the eight aids to the intellect, including the prerogative instances. "The list of prerogative or privileged instances are [*sic*] designed to help one pick out the kinds of case most useful to one's investigation."⁹ Although Gaukroger marks a sharp division between the stages here, in fact these aids have already been widely used (both because shining instances have just been employed and because many of the aids to the intellect are involved in the creation

⁹Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy*: p. 153.

of a natural history).¹⁰ The prerogative instances, in Gaukroger's view, are wide-ranging and embody techniques that previously could be found only in accounts of rhetoric.¹¹ Some of them are motivational, some are shortcuts, some help deal with unobservables, and there are many more.

What is not clear in Gaukroger's account is the relationship between the prerogative instances and eliminative induction. One might ask the question this way: what is it that makes the prerogative instances useful? Is it that they somehow help continue the eliminative procedure that has already begun? Gaukroger's emphasis on the eliminative procedure and comparatively quick discussion of the prerogative instances might suggest that this is his view, but he doesn't say so explicitly. Another possibility is that Bacon has already moved beyond the eliminative stage of the method. The view that I will later defend is a hybrid of these possibilities; sometimes the prerogative instances continue to do eliminative work, but sometimes their work is very different in nature.

The second major stage of Bacon's method is to test whether the formal cause has been successfully identified. Gaukroger holds that an axiom is true, according to Bacon, if and only if it yields practical fruit. So instead of a correspondence theory of truth, something like a pragmatist criterion of truth is ascribed to Bacon here. I believe this is a disastrous misreading of Bacon (although one that is shared by some other recent commentators¹²) which would lead to objections

¹⁰See, for example, A.1.2.1 on Instances with a Preparative Function.

¹¹The supposed rhetorical origins of some features of Bacon's method is turning out to be a hot topic of late, and I have no doubt that a close reading of ancient and Renaissance texts on rhetoric would turn up many interesting parallels to some of the prerogative instances. However, I fear there is a subtle causal fallacy being committed by those who overemphasize these parallels. Based on correlations between Bacon and the content of texts on rhetoric, it is assumed that Bacon consciously or subconsciously drew on those rhetorical texts for his ideas about methodology. It seems more likely to me that there is a common cause at work. That is, the same facts about the human mind which make certain rhetorical methods effective also make certain scientific procedures effective. So if Bacon and Quintilian, for example, independently take notice of those same facts and of their importance, it is not unusual that parallels might appear. I offer this worry as a justification for ignoring the possible rhetorical origins of Bacon's method throughout the rest of the chapter.

¹²Readings which tie truth too closely to practical success include those of Pérez-Ramos (who argues that Bacon is part of a Maker's Knowledge tradition) and Sophie Weeks (discussed below). For example, Pérez-Ramos says: "The ultimate criterion of a valid scientific statement appears to be success in operation." Pérez-Ramos, "Bacon's forms and the maker's knowledge tradition": p. 109

that, in my view, are worse than any created by the problem of underdetermination. This misreading must be corrected if we are going to understand Bacon's method and evaluate its merits fairly.

As his only textual evidence Gaukroger quotes Bacon from the *Valerius terminus*:

That the discovery of new works and active directions not known before, is the only trial to be accepted of; and yet not that neither, in case where one particular giveth light to another; but where the particulars induce an axiom or observation, which axiom found out discovereth and designeth new particulars. That the nature of this trial is not only upon the point, whether the knowledge be profitable or no; not because you may always conclude that the Axiom which discovereth new instances be true; but contrariwise you may safely conclude that if it discover not any new instance it is vain and untrue.¹³

Once the eliminative procedure converges on a single formal cause, Gaukroger says, we must check whether the axiom enlarges our power over the world. If it does, then the axiom is true. If it does not, then we must continue our investigation.

Oddly, the interpretation that Gaukroger offers directly contradicts the passage that he provides. True enough, the passage begins with the claim that the only good test for determining whether one has knowledge is one's ability to use axioms to discover new particulars. But Bacon quickly makes an important clarification. It is not true, he says, that axioms that discover new instances are always true. Sometimes false axioms lead to new instances. Therefore, the fruit of an axiom cannot confirm that axiom in the way that Gaukroger suggests. At most, the lack of practical results can falsify an axiom.

In fact, it is worse than this. For when Bacon talks in this passage about using the discovery of new particulars as a test or trial, he does not mean to refer merely to particulars that are practically useful. Bacon distinguishes between experiments of light and experiments of fruit and regards experiments of light as the more valuable of the two, criticizing those who obsess over experiments of fruit for behaving like Atalanta, who lost her race with Melanion because she kept stopping to pick up the golden apples that he tossed before her:

¹³As quoted in Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy*: pp. 155-6.

Therefore this above all has been and should be said again: that at the start and for some time after I seek experiments of light and not of fruit, following the example of the divine creation which, as I have said so often, on the first day brought forth light only, devoting to it alone one whole day, without getting involved on that day with any single work of a materiate nature. Thus if anyone thinks that things of this kind are useless, he is doing the same as supposing that light is useless just because it is not a solid or materiate. But in reality it should be said that well examined and defined knowledge of simple natures is like light which gives access to all the innards of operation, and with its particular power pulls together and draws down floods of works and of most noble axioms in its wake, but is still of no great use taken by itself.¹⁴

So here is one more respect in which Bacon rejects the pragmatist criterion of truth. It is not necessary that a true axiom point directly to new experiments of fruit since it might point to new experiments of light instead.

But this is not the end of the story either. Suppose we are inclined to accept some axiom but, as far as we can tell, it points to no new experiments of fruit or experiments of light. The *Valerius terminus* passage does suggest that now we can reject the axiom, for “you may safely conclude that if it discover not any new instance it is vain and untrue.” This is the reading offered by Sophie Weeks: “the failure to produce new particulars is a sign that inquiry has been diverted from its goal—an axiom which fails to discover *nova* is false. Conversely, the successful production of *nova* does not guarantee the validity of an axiom; rather it signifies only that the direction should be maintained.”¹⁵ This view, however, is philosophically problematic, which is, I suspect, why Bacon is more careful in the more polished *Novum organum*. The problem is that it is not obvious that true axioms always point immediately to new instances. If there are no immediate discoveries, how long do we wait? A year? Ten years? A hundred years? Bacon believes that true axioms always yield new instances, but if it might take a hundred years or more for them to do so, then the failure to discover those instances cannot be used to falsify the axiom until some unspecified amount of time has elapsed.

¹⁴*N.O.* I. 121.

¹⁵Weeks, “The Role of Mechanics in Francis Bacon’s Great Instauration”: p. 184.

There is a passage in the *Novum organum* which at first might seem to bolster Gaukroger's view, but I will argue that, properly understood, it still more deeply undermines him:

Among the signs none is more certain or noble than that derived from fruits. For the discovery of fruits and works [are like sponsors and financial backers of] the truth of philosophies. And from these Greek philosophies, and their ramifications down through the particular sciences, one can scarcely adduce after all this time a single experiment that tends to help and alleviate the human condition, and that can, properly understood, be truly credited to the speculations and dogmas of philosophy [...]. As so just as in religion we are admonished to show our faith by works, it is best if we do the same with philosophy and judge it by its fruits and, if it be barren, let us regard it as empty—the more so if instead of fruit of grape and olive it produces the thistles and thorns of disputation and quarrelling.¹⁶

This passage shows that *there are some circumstances* where Bacon believes that the lack of fruit falsifies axioms. But we must consider the nature of those circumstances more carefully. First, two thousand years had passed since the origination of the philosophies in question. It is not obvious that the same test could be used if only a few hundred years or less had passed. Consider the corpuscular theory of light, which, after it was advocated by Gassendi and Newton in the 17th century, bore little fruit and failed to account for many phenomena, despite the fact that it was the dominant paradigm. Yet today we have a fruitful theory which holds that light is made up of particles (albeit ones that have certain wave properties) called photons. I don't have a view about how long one might have to wait before giving up hope on a theory due its lack of results; perhaps this must be evaluated on a case-by-case basis. The point is that Bacon's rejection of ancient theories on the basis of their lack of results cannot be taken to imply his acceptance of a general principle that a theory's lack of practically useful results always falsifies it.

There is a second and still more important limit on the application of I. 73. Bacon refers to the first part of the *Novum organum* as the destructive part of the *Instauratio*. He there wrestles with a logical and rhetorical problem, namely, that he is attempting to persuade people to follow his method who at that time

¹⁶*N.O.* I. 73.

already had opposing methods of their own. Bacon cannot ask them to use his own method in evaluating his method, for they do not accept his method. Nor can Bacon ask them to use their own methods in evaluating his method, for in that case they would obviously reject it. Bacon responds to this dilemma as follows:

And here too I should draw the destructive part of my Instauration to a close, a part perfected in the three refutations, namely the refutation of Native Human Reason left to itself; the refutation of Demonstrations, and the refutation of Theories, or of received philosophies and doctrines. And the refutation of these has been only as it could be, which is by signs and testimony of causes; seeing that I (disagreeing with others on both principles and demonstrations) have no other way of confutation left open to me.¹⁷

Similarly, he says that “a knowledge of the signs prepares assent; an explanation of the causes removes the marvel, which two things will do much to render the extirpation of the idols from the understanding more easy and gentle.”¹⁸ When Bacon uses the fruitlessness of prior philosophies as evidence against them, he is, as he says here, using signs in order to refute them because, if he tried to use his positive method to refute them, they would simply reject his method.

We need to take a step back and ask what an argument from signs is. The classic example is the inference from the observation of smoke to the claim that there is a fire somewhere nearby. The smoke is a sign of the fire. For Aristotle, this kind of inference from signs is just one kind of reasoning and may figure both in theoretical science and in rhetoric. For the Epicurean school, all reasoning involves inference from signs. Bacon follows Aristotle more closely. At times, inference from signs does figure into his positive method of induction (see the discussion of Summoning Instances in Appendix A.1.1 on p. 251),¹⁹ but it is just one method among many at that stage. The destructive part of the *Instauration*, on the other

¹⁷*N.O.* I. 115.

¹⁸*N.O.* I. 70.

¹⁹Ian Stewart, expanding on some work by Ian Hacking in which he argues that Bacon has a rather flexible understanding of what counts as observation, has argued that summoning instances do not involve inference but actually change the content of our observations. But this interpretation would require Bacon to hold that sense-perception is theory-laden, and thus it is unlikely for the reasons provided in Chapter 3. Hacking, *Representing and Intervening: Introductory topics in the philosophy of natural science*: Ch. 10.

hand, reserves for semiotic inference an important rhetorical role. He does not argue for the validity of semiotic inference, but all of his opponents, including the Aristotelians, already accepted its validity. This means that using an argument from signs against his opponents is not necessarily question-begging, whereas using his method of induction against them would be.

It is debatable whether this particular argument from signs ought to succeed against an Aristotelian. I will come back to that question in 5.2.1 to briefly indicate how this strategy might offer a response to a mild form of the problem of the criterion. For now, the important point is just the interpretative one that far from putting forward a criterion of truth in I. 73, Bacon is making an argument that he regards as second best. It is made necessary by the epistemic situation of his opponents. And notice, furthermore, that this pragmatic test occurs before Bacon's positive, constructive method even begins—its purpose is to clear away certain idols so that the constructive part of the project can begin—whereas Gaukroger suggests that the test is the last stage of Bacon's positive method of induction and the one, oddly, which he seems to have the least objection to.

On the whole, there would be many good reasons for doubting the results of Bacon's method, if that method were as Gaukroger describes it. I hope to have flagged a few reasons for thinking that some revisions are in order.

5.1.2 Jardine

Lisa Jardine avoids many of Gaukroger's mistakes but still ends up with a basically negative assessment of the merits of Baconian induction. Again, I will try to show that it is a straw man version of Bacon that is largely to blame for this assessment.

Whereas Gaukroger understands Baconian forms as microscopic qualities that explain macroscopic qualities, Lisa Jardine states that forms are "essential definitions" or "true definitions of natural kinds."²⁰ This is close to the account of forms that I offered in Chapter 2, but it is not stated precisely enough. A definition is a mental and possibly linguistic item; forms are ontologically prior to definitions.

²⁰Jardine, *Francis Bacon: Discovery and the Art of Discourse*: pp. 121-2.

They are natures. The form of heat is the nature of a thing such that if and only if it has it does it count as an instance of heat. What Jardine should have said is that identifying the formal cause of a thing requires providing the definition of the kind to which that thing belongs. To say what the form is, one has to give a definition; but the form and the definition are not the same.²¹ Gaukroger's account, although too narrowly restricted to forms *of bodies*, has the virtue of avoiding this confusion. Jardine's account has the virtue of recognizing that providing definitions of natural kinds is an important goal of Bacon's method. This will be important in responding to worries about extrapolation that I mentioned at the start of the chapter.

It is also reassuring that Jardine recognizes that the section on the prerogative instances "occupies a very large part of the account of the inductive method in the *Novum Organum*" and that "[m]ost of the interesting observations which Bacon makes about scientific procedure are to be found amongst his remarks on specific instances with special prerogative."²² Unfortunately, her discussion of the prerogative instances is so brief that one can only wonder which "interesting observations" she has in mind.

It is a virtue of Jardine's account of Baconian induction that she recognizes that the prerogative instances play a role in the method from the beginning. Of particular note is her claim that migratory instances play a role in arriving at a provisional interpretation concerning whiteness in the *Valerius terminus*. "It should be noted that the inductive elimination is particularly simple in this case because prerogative *migratory* instances are selected from amongst all possible instances of occurrence of whiteness."²³ This is right in spirit, although it misreads the *Valerius terminus* discussion of whiteness. The purpose of the example is to illustrate the notions of certainty and liberty, not to illustrate the interpretation of nature. "Our purpose is now to give an example of a free direction, thereby to distinguish and describe it; and not to set down a form of interpretation how to recover and attain

²¹I was occasionally guilty of this confusion as well until Sam Rickless pushed me on this point. When I reread Bacon with this distinction in mind, I saw that Bacon himself never confuses forms and definitions even though he does see the two as closely related.

²²Jardine, *Francis Bacon: Discovery and the Art of Discourse*: p. 126.

²³*Ibid.*: p. 129.

it.”²⁴ We therefore cannot be sure that Bacon holds that migratory instances in particular should play a role prior to the provisional interpretation.

Ultimately, though, Jardine’s interpretation of Bacon, like Gaukroger’s, makes eliminative induction the centerpiece of the method. As for prerogative instances, Jardine is clearer than Gaukroger about the role that they have prior to the formation of a First Vintage, but they are still subordinate to the eliminative procedure for her. Their purpose is to get a natural history in good shape so that eliminative induction can do its work, whether that happens to be prior to or after the First Vintage. “Elimination between the table of presence and the table of absence provides the final stage in the inductive method. For Bacon this simple elimination between the tables is the only natural and legitimate use of formal inference in the interpretation of nature.”²⁵

For Gaukroger, elimination is the first stage of Bacon’s method; for Jardine, it is the last stage (epistemologically if not chronologically), the stage for the sake of which the prerogative instances exist. They agree that the prerogative instances, however philosophically interesting, do little to change the eliminative nature of the method.

So Jardine too believes that eliminative induction is the centerpiece of Bacon’s method. But remember that eliminative induction takes the form of a disjunctive syllogism where one premise sets out the possible explanations for a phenomenon and the other falsifies every possible explanation but one. It is by means of comparing tables, including the prerogative instances in those tables, that Jardine believes Bacon sets out to falsify the possible explanations.

This leaves the question of how the first premise of the disjunctive syllogism is to be grounded. Gaukroger, as we saw, suggested that Bacon has nothing interesting to say about this. Jardine, in contrast, has a very detailed account. She states that Bacon’s “starting point is a finite *a priori* list of simple natures”²⁶ and an *a priori* list of simple motions. The simple natures are the objects of def-

²⁴Bacon, *The Works of Francis Bacon: Philosophical Works*: Vol. 3, p. 237.

²⁵Jardine, *Francis Bacon: Discovery and the Art of Discourse*: p. 126.

²⁶Jardine, “*Experientia Literata* or *Novum Organum*? The Dilemma of Bacon’s Scientific Method”: p. 52.

inition or *definienda*; the simple motions, along with transcendentals, constitute the possible definitions or *definientia*. (Transcendentals, in Jardine's reading of Bacon, are "terms of mixed logical status." What this means, I gather, is that they can play the role of syncategorematic terms or auxiliary terms—logical operators being a paradigm example—but that they themselves can be objects of definition too. Some of Bacon's examples, listed by Jardine, are "*more, less, like, unlike, possible, impossible, being, non-being*."²⁷) Thus for each simple nature there is a finite number of possible explanations determined by all of the possible combinations of *a priori* simple motions and transcendentals. For example, heat—the simple nature—is to be defined in terms of the simple motions—it is after all a kind of expansive motion. She also seems to say that the definitions of these natures and motions (but not the makeup of the list itself, apparently) can be revised *a posteriori*.

What evidence does Jardine have that Bacon believes all of this? "Bacon's naive trust in *a priori* possibilities for isolating the primitive components that make up natural phenomena and natural processes derives, for him, from the fact that the Induction itself is the *second* stage in his method for investigating nature."²⁸ The first stage, she says, is the destructive part of the *Instauration* in the first book of the *Novum organum*. Bacon believes, she says, that by clearing away the idols, the destructive part will make available "clear and distinct" notions of the kind crucial for the initial selections and records of the Induction."²⁹ As further evidence she points to Bacon's belief in what I called first-level notions in Chapter 4. The problem with this reading is that Bacon only counts notions of *infima species* and of the immediate apprehensions of sense-perception among the first-level notions; neither notions of simple natures nor notions of simple motions are included. Indeed, given how abstract the notions of simple natures and motions are, Bacon's gradualism should imply that they are very far up in the hierarchy of knowledge. (It is also worth noting that Jardine appears to be conflating the

²⁷Jardine, "*Experientia Literata* or *Novum Organum*? The Dilemma of Bacon's Scientific Method": p. 54.

²⁸Ibid.: pp. 53-4.

²⁹Ibid.: p. 54.

foundational with the *a priori*, or at least the plausibility of her argument depends on her not carefully making this distinction.)

Jardine does not say where she gets the idea of simple motions. A listing of these appears late in the *Novum organum*, but the best evidence for distinguishing between simple natures and simple motions comes from the *Abecedarium novum naturae*. The *Abecedarium* begins with a classification of what Bacon there calls “forms of the first class,” and there is reason to believe that this is another way he has of referring to simple natures.”³⁰ Sure enough his list does include typical examples of simple natures such as *hot, cold, dense, rare, tangible, and pneumatic*. When the list of forms of the first class is done, he moves on to a discussion of the simple motions. They include *resistance, connection, elasticity, continuity*, different kinds of *congregation, disposition, assimilation, excitation, impression, spontaneous rotation*, and more. Furthermore, Bacon says, these simple motions can be compounded. This gives rise to the next section of the treatise on the sums of motions, which include *corruption, conservation, growth, metamorphosis, local motion*, and several others. When we take this classification of natures and motions in conjunction with Bacon’s own examples of definitions (such as the definition of heat as a modification of motion), one gets some initial support for Jardine’s claim that the simple natures are to be defined directly or indirectly (via the sums of motions) in terms of the simple motions.

Nevertheless, Jardine’s account of the justification of the disjunctive premise in an eliminative induction is on the whole unsatisfying for reasons both textual and philosophical. First, it would be shocking if Bacon believed that a list of simple natures or simple motions could be known *a priori*. There is no evidence that Bacon believes that anything can be known *a priori*. The very first aphorism of the *Novum organum* suggests the opposite. “Man, the servant and interpreter of nature, does and understands only as much as he has observed, by fact or mental

³⁰The evidence for the equivalence of simple natures and forms of the first class is *De augmentis*, Vol. 4, p. 361. A problem for Jardine, though, is that this passage also states that the motions are included among the simple natures. This is in conflict with the *Abecedarium* passage. The dates of composition of the works aren’t of much help: the *Abecedarium* was written in the spring or summer of 1622, and the *De augmentis* was published in 1623. The phrase “forms of the first class” is not in the earlier English version.

activity, concerning the order of nature; beyond that he has neither knowledge nor power.”³¹ The *Abecedarium* itself states that

The titles by which the order of the Abecedarium has been laid out should by no means be accorded the authority of true and fixed divisions of things. For this would be to claim that we know the things we are inquiring into. For no one who has not thoroughly investigated their nature apportions things truly. Let it be sufficient if that which we now speak of is convenient for the course of inquiring.³²

This passage seems to affirm not only that the definitions of each listed nature are not yet known, but that the makeup of the list itself (the titles and the divisions) is corrigible and that it not only might change but should be expected to change. It also suggests, as one would expect from Bacon, that the only epistemic basis for the list is experience.

An *a priori* list of simple natures and motions is also philosophically unsatisfying. Our experience is confined to a narrow domain. It has spatial and temporal boundaries, and it is generally restricted to the macroscopic scale. How can we possibly know that natures outside of this domain will be the same ones suggested by ordinary sense experience? If there is in fact no *a priori* knowledge of simple natures, then a purportedly *a priori* list of them is a recipe for the very sort of reliance on habitual experience that Bacon condemns.

Jardine’s reading leads her to an important conclusion about the certainty of Bacon’s method: “Only if the list of simple natures is correct and the history is complete can the simple elimination produce the final form of the simple nature under investigation.”³³ If the *a priori* list is faulty, then the disjunctive premise is weak; if the history is incomplete, then one will not be able to falsify every possible explanation for a simple nature but one. All one can do in these less than ideal circumstances is to produce a First Vintage.

³¹*N.O.* I. 1. I grant that it is unclear what it means to observe something about the order of nature via one’s mental activity. It may refer to observing *that* something is true via an inference or to observing one’s own mental states. I don’t think it can be persuasively argued that it allows room for the *a priori*.

³²Bacon, *The Instauration magna: Last Writings*: 36^v 17-22.

³³Jardine, *Francis Bacon: Discovery and the Art of Discourse*: p. 127.

This interpretation thus leads quite naturally to Jardine's view that Baconian induction must fail in its endeavor for certainty. The possibility of certainty, she thinks, depends on *a priori* metaphysics, yet Bacon also wants to be an empiricist. Bacon, Jardine thinks, fails to bridge the gap between his empirically minded histories and his metaphysics. If we reject Jardine's view that Bacon's starting point is an *a priori* list of simple natures and simple motions, then her negative assessment of Bacon's success will require some rethinking.

5.1.3 Urbach

Peter Urbach is more sympathetic towards Bacon than either Gaukroger or Jardine; indeed, his appraisal of Bacon is basically positive. The purpose of his book on *Francis Bacon's Philosophy of Science* was to defend Bacon against the previous generation of critics—but the means of defense, unfortunately, was to turn Bacon into little more than a precursor of a run-of-the-mill 20th century hypothetico-deductivist. The message that Urbach in effect sends is that Bacon is not a source to turn to for new ideas, but that we can still appreciate the fact that he had our own ideas long before we did. Needless to say, that message stands in direct contrast to my own, which is that Bacon can teach us quite a bit if we will only work to understand him more fully.

Urbach's book is structured as a response to what he calls the standard interpretation of Bacon. This standard interpretation includes a number of features which he refers to collectively as the infallible-mechanical thesis: the claim that the Baconian method is a rote, mechanical procedure which will necessarily lead to epistemically certain knowledge of causes for anyone who follows it. This thesis has a number of additional components, some of which have cropped up in Gaukroger's and Jardine's objections to Bacon as well (even though Jardine was not Urbach's primary target and Gaukroger's book had not been published yet):

1. It includes the claim that the means to this certainty is supposed to be the method of eliminative induction, "whereby all accounts but the true one are excluded."³⁴

³⁴Urbach, *Francis Bacon's Philosophy of Science: An Account and a Reappraisal*: p. 18.

2. Eliminative induction further requires the “principle of limited variety,” which states “that the world is composed of a large number of ‘concrete’ or ‘compound’ bodies, such as lions and gold, each of which can be analyzed into a finite number of ‘simple natures’, or properties.”³⁵ In contrast to Urbach, I take it that Bacon does believe this principle.
3. It says that the aim of science is to discover the forms of those simple natures by finding some other simple nature which is present in a concrete body if and only if the simple nature being investigated is also present.
4. For the eliminative method to work, we need to be able to enumerate all of the simple natures present in a concrete body along with the simple nature we are investigating, so concrete bodies must always have a finite (and small) number of simple natures. As we saw, Jardine not only attributes this view to Bacon but says moreover that the list of simple natures (and of simple motions) is known *a priori*.
5. According to Urbach, the thesis also appeals to the claim that science should rid itself of hypotheses and that history should consist in pure facts without any tinge of theory. I take it that this aspect of the infallible-mechanical thesis has been addressed by the previous chapter, and I will not spend any more time on it.

Urbach agrees with Bacon’s critics that this standard interpretation of Bacon, if right, would mean that there is little of value in Bacon’s philosophy of science.

But Bacon does not accept the infallible-mechanical thesis, according to Urbach: he did not advocate eliminative induction, since elimination is just the first stage of his method, and he did not believe that his method would lead to absolute certainty but only to psychological or moral certainty. Bacon’s objections to skepticism, discussed in Chapter 2, already rule out the idea that Bacon is only after psychological or moral certainty, so I want to focus on Urbach’s reasons for rejecting the standard interpretation of Bacon as a proponent of eliminative induction.

³⁵Ibid.: p. 19

Urbach describes Baconian induction as a three-stage process where the first stage is the eliminative one, the second is the generation of a hypothesis in the form of a First Vintage, and the third is the augmentation of the First Vintage using additional aids to the intellect, such as the prerogative instances (although Urbach also correctly recognizes that some of the prerogative instances are involved earlier, both in the creation of histories and in the generation of the First Vintage).

The claim that the method of elimination is just the first stage of induction and is not intended to converge on a single explanation requires a new gloss on some of the passages that are typically taken as evidence for the standard interpretation. For example, when Bacon says that “In the process of exclusion are laid the foundations of true induction,” we should highlight the word “foundations,” says Urbach, “suggesting the superstructure must be built out of different materials.”³⁶ And although Bacon claims that “a Form affirmative, solid and true and well-defined” will remain after the process of elimination is done, Urbach notes that Bacon immediately adds that although “This is quickly said...the way to come at it is winding and intricate.”³⁷ Perhaps that winding and intricate path involves moving beyond the eliminative stage of the method.

It might be thought that Bacon’s account of crucial instances poses another objection to Urbach’s argument. After all, crucial instances seem to be instances that allow one to complete the process of elimination. Despite appearances, Urbach says, the method embodied by crucial instances is not an eliminative one. First of all, he says, crucial instances do not analyze concrete bodies into simple natures. They instead seem to involve the choice between two competing theories. And second, they do not involve eliminating the last of the possible explanations for a phenomenon. Instead, they might involve the choice between two hypotheses where each is the logical negation of the other, or at least between two hypotheses that are mutually exclusive and exhaustive, and if not *logically* exhaustive, then at least exhaustive of all of the reasonable possibilities. Urbach is unclear which one of these conditions on the hypotheses is required for a crucial instance, possibly

³⁶Urbach, *Francis Bacon’s Philosophy of Science: An Account and a Reappraisal*: p. 179, quoting II. 19 of the *Novum organum*.

³⁷Ibid. This is Urbach’s quotation of *N.O.* II. 16.

because he thinks that Bacon himself is unclear.

If the eliminative stage of the method is not intended to converge on a single explanation, then what is its purpose, according to Urbach? “The sudden change in style of expression between the section dealing with the tables and that concerned with the First Vintage suggests that the aim of the rejections was not the discovery, or even the elimination of forms themselves, but of surface manifestations of those forms.”³⁸ If this is right, then the eliminative stage of the method is of quite limited value. If the method ruled out possible explanations but failed to converge on a single one, then at least it would be of great value in narrowing down the space of possible explanations. But Urbach says that it does not even do this much. He does not quite put it this way, but the upshot seems to be that the eliminative stage helps guide further investigation by clarifying the *explanandum*, not by narrowing down what the *explanans* might be.

This means that the second stage of the method, the stage of hypothesis-formation in the form of the First Vintage, introduces its conjectural explanations not thanks to other explanations having been ruled out, but through a creative leap (a leap that is perhaps motivated more by the shining instances than by the eliminative procedure). Although I will argue that Urbach goes too far in undermining the importance of the eliminative stage and that it does narrow down the *explanans*, to a certain extent Urbach is right. The First Vintage does not follow logically from the eliminative stage, and shining instances do indeed play an important role in the formation of the First Vintage.

After the First Vintage, one must apply nine additional aids to the intellect. Of these, Urbach, following Bacon, discusses only the prerogative instances in any detail. He divides the prerogative instances into two categories, those “Useful for the Initial Survey of Phenomena” in the natural histories and those “Useful for the Induction of Axioms.”³⁹ Urbach, like Gaukroger and Jardine, provides no integrated account of the prerogative instances beyond this broad grouping, instead just choosing a handful of examples and summarizing them.

Urbach mentions that some of the prerogative instances are related to Ba-

³⁸Urbach, *Francis Bacon's Philosophy of Science: An Account and a Reappraisal*: p. 183.

³⁹Ibid.: pp. 164-66.

con's ideas about natural kinds and species and mentions the instances which involve "unusual or extraordinary" phenomena (Monadic instances and Frontier Instances) as examples. I think he significantly underestimates how many of the prerogative instances are related in some way to Bacon's ideas about natural kinds. This will be an important part of my own interpretation, whereas Urbach thinks that it is one of the embarrassing features of Bacon's method:

Bacon took no trouble to defend this doctrine of species and prodigies, which is, perhaps, just as well, for he showed no awareness of the fact that what might seem like a natural grouping of phenomena into a species and what appears to be an unrepresentative instance of such a species are both influenced by one's theoretical point of view. I am thus not inclined to set much value on Bacon's idea, though it has a close affinity with the now widely held theory that objects and phenomena may enjoy an essential similarity, by virtue of belonging to the same so-called natural kinds.⁴⁰

In the course of my own interpretation, I will argue that the doctrine of natural kinds is an essential feature of Bacon's method without which it cannot be fully understood or defended (particularly in light of the problem related to extrapolating to a whole *type* of phenomenon). I will also argue that his ideas about natural kinds do not neglect the point that groupings of phenomena are influenced by one's theoretical point of view. Instead, some of Bacon's prerogative instances are designed to work towards achieving a more accurate and more certain theoretical point of view (in keeping with the revision processes discussed in Chapter 4).⁴¹

To summarize, then, the main weaknesses of Urbach's reading are his failure to take seriously the prerogative instances dealing with natural kinds, his failure to appreciate the fact that the method of exclusions plays an important role in justifying the First Vintage (and his inaccurate restriction of the method of exclusions to surface manifestations of forms), and the fact that his summary of the prerogative instances is so cursory that it is unclear how any of them are supposed to do any justificatory work.

⁴⁰Urbach, *Francis Bacon's Philosophy of Science: An Account and a Reappraisal*: p. 163.

⁴¹See p. 191ff.

5.1.4 McCaskey

An important recent defense of Baconian induction comes from historian John McCaskey. McCaskey's Bacon is radically different from the Bacon of Gaukroger, Jardine, or Urbach. In contrast to Gaukroger and Jardine, McCaskey does not regard the method of elimination as the most important or most essential feature of the inductive process. In contrast to Urbach, he does not read Bacon as a precursor to modern fallibilist-deductivists—quite the contrary, for he reads Bacon as reviving and systematizing the Socratic theory of induction, which he argues (Bacon's hostility to Aristotle notwithstanding) was the blueprint for Aristotle's theory as well. He is also the only Bacon scholar I am aware of other than myself who believes both that Bacon is after epistemic certainty concerning formal causes and that he has the resources to attempt a defense of this aspiration against some of the usual objections. Ultimately, though, I will argue that McCaskey's account is at best incomplete because it does not explain what distinguishes a First Vintage from a conclusively justified axiom.

Let us begin with Socratic induction. McCaskey argues that historically there have been two broad conceptions of induction. There is the Socratic tradition, where induction is regarded as a method for forming and defining concepts and then justifying universal statements by means of those concepts, and there is the tradition initially rooted in the scholastics where induction is regarded as a logic of propositional inference for inferring universal statements from particular ones.⁴²

McCaskey neglects an important distinction here which it is worth clarifying. Socratic induction is itself an ambiguous term and at times McCaskey alternates surreptitiously between the two meanings. (The term *epagōgē* does not appear in any of the surviving Platonic dialogues, so using the term in either of the following ways could be legitimate, so long as we keep them distinct.) For convenience, I will coin distinct terms for the two kinds of Socratic induction: local Socratic induction and global Socratic induction. The reason for these terms will become clear in a moment.

⁴²My way of framing McCaskey's view has been influenced by his "Induction in the Socratic Tradition."

McCaskey begins his discussion of Socratic induction by pointing to a passage where Aristotle ascribes the method to Socrates:

Socrates was occupying himself with the excellences of character and in connection with them became the first to raise the problem of universal definition. . . . It was with good reason that he should be seeking the essence, for he was seeking to argue deductively and the beginning [archē] of deductive arguments is the essence. . . . For two things may be fairly ascribed to Socrates—inductive reasoning and universal definition, both of which are concerned with the the starting point of science [archēn epistēmēs].⁴³

McCaskey then spends some time determining which passages in Plato's dialogues might represent the kind of induction that Aristotle has in mind. An important piece of evidence for him is Aristotle's definition and example of induction in the *Topics*: "Induction, however, is proceeding from particulars up to a universal. For instance if the pilot who has knowledge is the best pilot, and so with a charioteer, then generally the person who has knowledge about anything is the best."⁴⁴ This example is strikingly similar to a certain kind of argument that one does indeed frequently find in Plato's dialogues, especially the early ones. McCaskey focuses on an example from the *Ion* since it was previously analyzed by Vlastos, but an even more similar passage in the *Euthydemus* can be summarized as arguing the following:⁴⁵

1. (Wise) flute-players are both most fortunate and most successful in playing the flute.
2. (Wise) scribes are both most fortunate and most successful in writing and reading letters.
3. Wise pilots are both most fortunate and most successful in sailing.
4. Wise generals are both most fortunate and most successful in war.

⁴³As quoted by McCaskey from Ross's translation of Aristotle's *Metaphysics*, 13.4 1078b 24-30. McCaskey, "Regula Socratis: The Rediscovery of Ancient Induction in Early Modern England": p. 31.

⁴⁴Ibid.: p. 21.

⁴⁵Plato, *Plato: Complete Works*: 279e -280b.

5. Wise physicians are both most fortunate and most successful in treating illnesses.

The conclusion from these five premises is that wisdom in a domain always makes men fortunate and successful in that domain. Note that this conclusion is not supported merely by an enumeration of particulars, as is evidenced by Socrates' summary statement at 280a that the wise man "must act rightly and succeed, or his wisdom would be wisdom no longer." In other words, no counterexample is possible. Show Socrates an example of a man who fails in some domain and he can tell you without further information that the man is not wise in that domain. The examples of wisdom are not to be understood as particular instances which confirm a generalization but as exhibitions of the meaning of the concept of *wisdom*.

Here is an example of Aristotle arguing in a similar manner:

Let us add to this assumption the further statement that virtue is the best condition or state or power of whatever has a use or has work to do. This is clear from induction; in all cases this is what we suppose. Because a cloak has a use and has a work to do, there is such a thing as the goodness or virtue of a cloak, that is to say, the best state for a cloak to be in. So too with a boat, a house, and other things. The case is the same with the soul, for it too has work to do.⁴⁶

Aristotle's conclusion is that virtue or excellence is the best state of anything that has a function. Again, a counterexample would be impossible. Aristotle's examples exhibit what excellence means such that, if you pointed to something that had a function and called it excellent while it was in bad state, Aristotle could rightly respond that you are failing to understand what excellence means and that you should invent a different term for whatever it is that you have in mind.

Historically, this kind of argument (though not necessarily understood in the way both McCaskey and I understand it, as exhibiting the meaning of a concept) is what is most often called Socratic induction. McCaskey finds an awareness of this kind of induction beginning to reemerge in the Renaissance in Rudolph Agricola's *De inventione dialectica*:

⁴⁶Aristotle, *The Eudemian Ethics*: 219a.

[One] asks whether it is admitted that the soul is better than the body. But this also must be built up from a *Socratic induction*. It must be asked whether the driver is superior to his chariot, the helmsman to his ship, the master to his house, and the ruler to his people, or in general whether he thinks that that which commands is superior to that which serves, and whether he thinks the body is ruled by the soul. Which if he concedes it, it will be necessary for him to concede that the soul is superior to the body.⁴⁷

This growing awareness of Socratic induction suggests that Bacon too may have been aware of a tradition other than the scholastic one that he could draw on. And McCaskey cites the following passage from Bacon as evidence that he does indeed draw on that tradition:

Now to set up our axioms we must think up a form of *Induction* other than the one in use hitherto, and one not just for grounding and discovering principles (as they call them) but also for the lower and middle axioms and, indeed, all of them. For induction proceeding by simple enumeration is a childish affair, its conclusions are unsafe, it opens itself to the threat of the contradictory instance, and generally bases its verdict on facts fewer than necessary, and among these only the ones which are readily available. But the *Induction* to be employed for the discovery and demonstration of the sciences and arts ought to separate a nature out by due rejections and exclusions, and then, after bringing enough negatives to bear, draw conclusions from affirmatives; which is something never yet done or attempted hitherto, except by *Plato* alone who does to some extent use this form of induction for scrutinising definitions and ideas.⁴⁸

The claim that Plato is the only precursor of Baconian induction seems to confirm that Bacon's induction should be understood as an outgrowth of the Socratic tradition.

The problem is that Socratic induction as usually understood was not directly used for "scrutinising definitions and ideas." Bacon doesn't seem to have in mind passages like that in the *Euthydemus* here. Instead, he seems to have in mind the *elenchus* as a whole. The point is that Plato, like Bacon, asks about a

⁴⁷As quoted by McCaskey from Jardine's translation in "Humanistic Logic," p. 183. McCaskey, "Regula Socratis: The Rediscovery of Ancient Induction in Early Modern England": p. 135. The corrections to the punctuation and the italics are McCaskey's.

⁴⁸*N.O.* I. 105.

given nature, “What is it?” and progresses towards an answer by first eliminating or excluding candidate answers by showing how they lead to contradictions with other accepted premises. I will call this global Socratic induction because it is the overarching method in many of the dialogues. It is distinct from the local Socratic induction used to establish particular premises during the course of the discussion. Local Socratic induction, in contrast to global, does not employ the method of exclusions that Bacon is talking about in the above passage.

McCaskey believes that Bacon, in placing himself in the Socratic tradition of induction, means to say that he thinks of induction as fundamentally about notion-formation rather than as about propositional inference. While it is true that Bacon does believe that the primary function of induction is to discover and justify notions and their definitions, this is not the reason he refers to Plato as his only precursor.

According to McCaskey, the Socratic tradition of induction, understood as an approach to induction which takes concept-formation as its primary function, is the key to Bacon’s ideas about certainty. To see this, first ask what kinds of things Bacon wants to be certain about. McCaskey observes that Bacon wants to effect changes in physical objects with certainty.⁴⁹ He wants to know with certainty that if such-and-such a motion is generated in an object, then it will be hot. McCaskey then argues that possessing a true definition of heat, one which states its formal cause, makes this possible. If heat just is such-and-such a kind of motion, then no exception is possible; whenever that motion is present, heat will be the inevitable result.

An important aspect of this interpretation is the claim that this process of notion-formation is not a process of propositional inference. The primary product of any induction is not a universal proposition but a notion, and that notion is not argued for by setting out premises and making arguments based on them but is rather formed by comparing and contrasting the referents of the notion. According to this reading, not only the three tables but also the twenty-seven prerogative instances are there to facilitate the comparing and contrasting of the instances.

⁴⁹If we restrict the discussion to natural science, then this is right, but it raises the question of whether Bacon is concerned at all with certainty in the science of man.

This compare-and-contrast process makes possible the abstraction of the notion.

Baconian induction is therefore not eliminative induction. It is true, according to McCaskey, that one feature of Bacon's method is the elimination of some candidate definitions of a nature by means of his compare-and-contrast method. But this process of elimination is not part of an inferential argument, not even of a probabilistic one. What exactly is its function, then? As far as I can tell, McCaskey doesn't say. Often he talks as if the process of elimination, like the rest of the compare-and-contrast process, is a heuristic to help one intuit the form.

Even if that is not quite right, McCaskey overstates the contrast between propositional inference and concept-formation. Bacon's view seems to be that there is no dichotomy between inference and abstraction. It is true that Bacon is primarily concerned with forming well-defined notions, but as Bacon sees it, propositional inference plays an important role in that process of notion-formation (unless the notions are first-level and therefore directly abstracted from sense-perception, which performs the compare-and-contrast process automatically). Furthermore, the notions that Bacon seeks require true definitions in order to count as well-defined notions, and those definitions themselves are propositions.

There is another major shortfall of the argument thus far. It equivocates between two meanings of the term "certainty" in the same way as Jardine, et. al. in Chapter 2. According to one technical meaning, discussed in Chapter 2, certainty refers to universal predication. According to the second meaning, it refers to a conclusive degree of epistemic justification. McCaskey is right that the discovery of definitions explains the possibility of certain rules for effecting changes, if we take "certain" in the first sense. Those rules will have no exceptions if we have genuinely discovered the formal cause. But it does not follow that we can be epistemically certain of our rule—not unless we are also epistemically certain of our definition. So far, then, McCaskey has just pushed the problem of induction back a level. We no longer need to ask how we can be certain that all friction produces heat. Our definitions of heat and of friction, if they are certain, will give us an answer with certainty. But so far there is no answer to the question of how we can be certain of the definitions themselves.

Fortunately, McCaskey does have a little more to say. The most persuasive way to set out his view is to begin with his examples of epistemically certain definitions. For example, he points to the evolution of the concept of cholera. Initially, the concept was defined nominally, by reference to a cluster of symptoms. With the concept in that state, no certain, universal statements could be made about how to avoid contracting cholera. But eventually, cholera was redefined causally as an infection caused by the bacterium *Vibrio cholerae*. With this “mature” definition, we can now be certain that if we avoid that bacterium, we will avoid cholera.

Furthermore, McCaskey says, we can be certain of this new definition. What licenses that certainty is the same as what licenses Socrates’ certainty in the *Euthydemus* passage. If someone pointed to something not caused by the bacterium *Vibrio cholerae* and called it cholera, you would respond that, however similar to cholera it appears to be, it is not actually cholera—because cholera just is an infection caused by that bacterium. No counterexample to our definition is possible. Now we see the importance in McCaskey’s view of regarding Bacon as a proponent of Socratic induction; it is this feature that is most evidently displayed by *local* Socratic induction that is of central importance for him, although I suppose McCaskey would argue that global Socratic induction has the same feature.

Examples such as the discovery of cholera are plausible enough, but how do we know when our concepts have matured to the point of warranting this rejection of counterexamples? Bacon’s First Vintage concerning heat states that it is a kind of expansive motion. This definition purports to point to the form of heat just as much as the above definition of cholera purports to point to the form of cholera; Bacon’s definition cannot be dismissed as an immature nominal definition. If you point Bacon to a case of contractile motion that is hot to the touch, should he respond that, however superficially similar the instance appears, it is not a genuine case of heat because if it were, it would be an instance of expansive motion? This reply no longer seems very satisfying. Is Bacon’s concept of heat not yet *fully* mature? Perhaps not. But why not? McCaskey does not say what distinguishes it from the concept of cholera. How do we distinguish a provisional interpretation from a perfected one?

Despite this missing piece in McCaskey's account, he offers a useful starting point for further investigation. Now we know one possible route to epistemically certain generalizations, epistemically certain definitions which state the formal cause of a phenomenon. If we can find resources in Bacon for distinguishing between First Vintages, which are still subject to revision, and mature definitions, which can no longer be reasonably doubted, then we will be on solid footing.

5.2 A New Interpretation of Bacon's Method

With the above interpretations of Bacon's method of induction as foils, I now turn to my own interpretation. My overall interpretation, and *some* of the main points of contrast with the interpretations discussed above, can be summed up by Figure 5.1 below. Note that although McCaskey has misidentified the feature of induction which Bacon locates in Plato's dialogues, I nevertheless build on his view that proper notion-formation is of paramount importance to Bacon's quest for certainty. But whereas McCaskey locates this process of notion-formation in the compare-and-contrast process that leads up to the First Vintage, and then implies that Bacon believes nothing more needs to be done to reach certainty, the bulk of the notion-formation process occurs when Bacon employs the prerogative instances related to our search for natural kinds (the ones that Urbach dismisses as unhelpful).

In 5.2.1, I address the destructive part of the *Instauratio*, which in my view offers an interesting justification for believing the method a reliable one. In 5.2.2, I address the eliminative stage of the method of induction, which certainly exists and plays a justificatory role. However, Gaukroger and Jardine overstate the importance of the eliminative stage, while McCaskey and Urbach understate its importance. (Recall that Urbach treats the First Vintage as a bold conjecture.) In 5.2.3, I turn to the prerogative instances, especially those which have a non-eliminative character.

Note that Bacon's method is pluralistic, in that it allows for multiple paths of justification—I think of it as providing a toolbox—and contextual, in that dif-

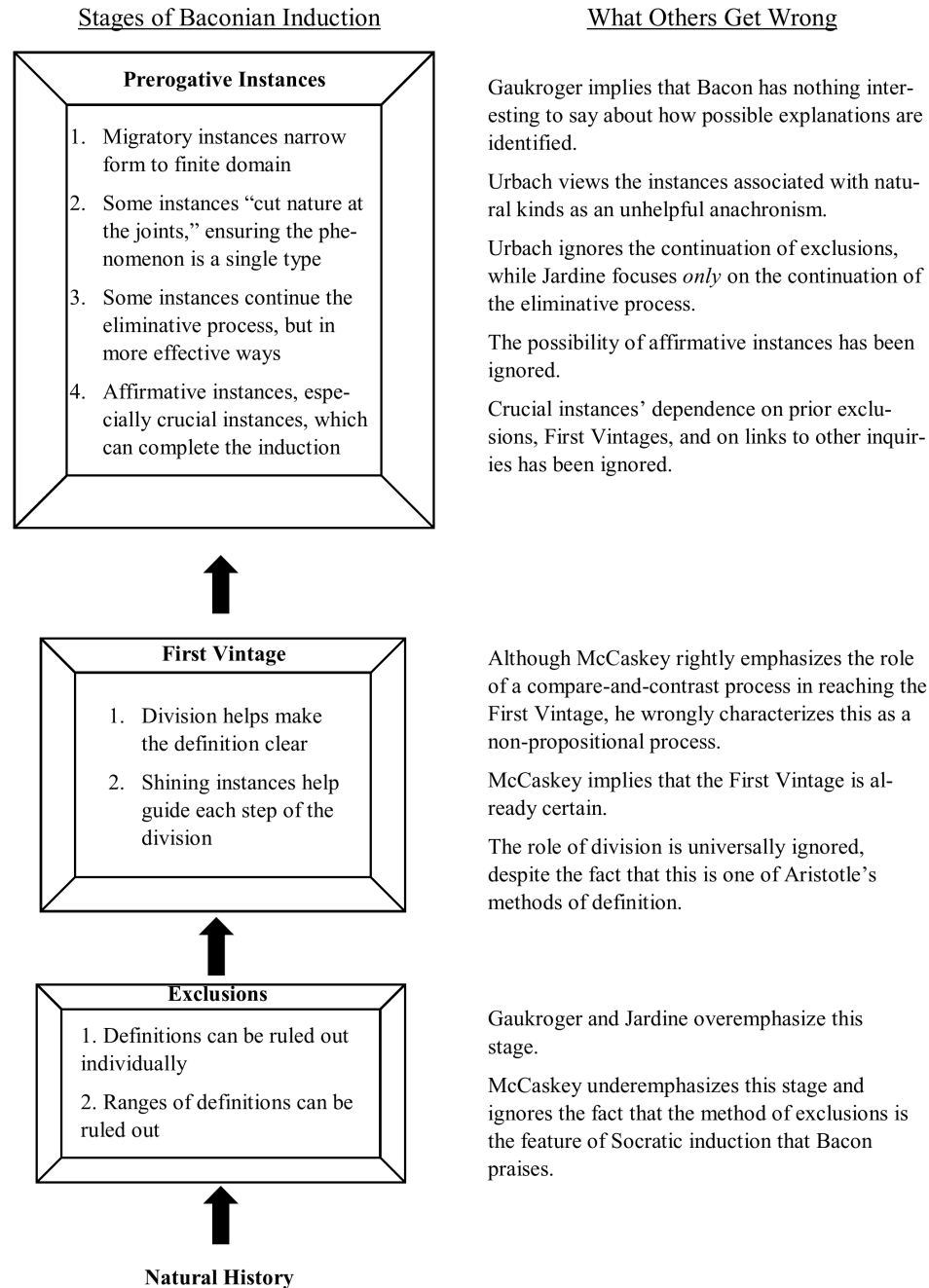


Figure 5.1: The Stages of Baconian Induction

This figure summarizes Bacon’s various tools at each stage of the inductive process and points to some of the main failings of alternative interpretations.

ferent paths suit different inquiries. Therefore, there is not just one way to tie all of the features of the method together. (Imagine asking a carpenter to explain how his toolbox comes together to build stable structures, without naming a particular structure.) If I could choose just one point about the method to emphasize, though, it would be the mostly non-eliminative nature of the prerogative instances, because it is the interpretation of Bacon as an eliminativist which leaves him vulnerable to the problem of underdetermination.

5.2.1 Destruction and a New Beginning

The destructive part of Bacon's method roughly corresponds to the material in Book I of the *Novum organum*. This stage of the method is made necessary by three kinds of facts that give rise to the famous idols (idols are false notions and axioms): (1) there are facts about the human mind that make us susceptible to confirmation bias and other biases, (2) there is the fact that most scientists already accept methodological ideas opposed to Bacon's own (such as Aristotelian ideas), (3) and there is the fact that many of their ideas and theories are false, and given that Bacon recognizes the role that theories play in shaping the development and analysis of natural history, that is a problem. Bacon's purpose in the destructive part is to wipe the slate clean by identifying these causes of the idols so that we can counteract or control them.

Here I want to focus on (2) as a possible source of skepticism about the results of Bacon's method. Suppose Bacon's opponents are committed scholastics. They have their method, and Bacon has his. If the results of Bacon's method are going to have any hope of being counted as justified beyond a reasonable doubt, in light of this, then it seems Bacon will need to be able to show that doubts based on alternative possible methodologies are unreasonable. One can imagine an exchange between Bacon and a scholastic going as follows:

Bacon: Here are some experiments that prove that my method is the right one!

Scholastic: Experiments, you say? Hold it right there. Experiments are artificial. We're trying to discover the way things really are, not the way they are when we manipulate them.

One cannot presuppose a method in arguing for that method and expect it to be persuasive. So how can Bacon prove to his opponents that they should discard their own method and adopt his? In my view, he has two basic strategies: the argument from signs that I mentioned in discussing Gaukroger's interpretation, and the view that axioms about methodology are to be discovered and justified by induction and may be revised over time in the same way as other axioms. The first strategy is a means to getting started on the second.

I mentioned that the argument from signs seems promising because it is a method of inference already accepted by his opponents. Thus Bacon does not need to presuppose his own method in order to argue that the method of his opponents is wrong. But can Bacon really make a persuasive case to them?

The signs that he points to as evidence that the prevailing method is wrong are the following:

1. The place of philosophy's origination: it comes from Ancient Greece, which was disputatious, petty, and professorial.⁵⁰
2. The character of the time and age when philosophy originated: mankind hardly had any history to draw on. It was a primitive time.⁵¹
3. The method is barren of works. Bacon mentions recent inventions such as the compass, gunpowder, and the printing press, but most inventions are straightforward extensions of the same handful of accidental discoveries.⁵²
4. The sciences have been in a state of stagnation. One would expect that we would keep discovering more and more about the universe if our method were correct.⁵³
5. The proponents of the prevalent method express despair about the limits of our knowledge.⁵⁴

⁵⁰*N.O. I.* 71.

⁵¹*N.O. I.* 72.

⁵²*N.O. I.* 73.

⁵³*N.O. I.* 74.

⁵⁴*N.O. I.* 75.

6. Adherents to the prevalent method disagree with each other about doctrine and are unable to resolve those disagreements by means of their method.⁵⁵
7. Its popularity is evidence that the method appeals to the imagination or to the idols rather than to reason.⁵⁶

Note that these signs do not need to *prove* the falsity of the prevalent method. They need only persuade followers of the prevalent method to set it aside at least temporarily in order to try an alternative. The hope is that when they do try out Bacon's method, it will begin to offer evidence of its own correctness.

As history demonstrated, these signs were more persuasive to the next generation of budding scientists than they were to already committed scholastics, who would have had many counterarguments to offer.⁵⁷ The signs also became more persuasive after the full potential of the scientific revolution became evident on a scale that could not be ignored, to the point where today a pharmaceutical company that only discovered one new drug in a century would be regarded as obviously dysfunctional.

For those who do try out Bacon's method, how can they prove to themselves that the method is reliable? Is it viciously circular if they use the very method they have adopted to show that their axioms of methodology are true?

Bacon's view is that the revision and self-correction mechanisms of Chapter 4 apply here as well, so there is no vicious circularity required. I would add that for this to succeed, there must be at least one methodological axiom which, like a first-level notion relative to other notions or a properly basic belief relative to other beliefs, can be justified without appealing to other methodological axioms

⁵⁵*N.O.* I. 76.

⁵⁶*N.O.* I. 77.

⁵⁷Probably they would just disagree with Bacon's assessment of Ancient Greece in (1). (2) seems to presuppose that methodology should be discovered inductively on the basis of history, or at least (2) is less persuasive without that presupposition. (3) presupposes that the purpose of knowledge is power over the world, but a diehard scholastic would respond that contemplation is its own end and that the best life does not require advanced technology. (4) and (5) presuppose that something better is possible. (7) at best presupposes Bacon's faculty psychology and at worst is a reversal of the *ad populum* fallacy (sometimes called the argument from snobbery). The most persuasive sign seems to me to be (6), which I have a hard time imagining a response to that is not *ad hoc*.

either directly or indirectly (by appealing to anything that requires methodological axioms for its justification). We can call these first-level methodological axioms.

While I think this basic approach is implied by Bacon's method, he does not himself justify his method by beginning with first-level methodological axioms and going through an iterative process of revision, expansion, and correction. It is easy to understand why not; this would be a Herculean task, and an unnecessary one for anyone who is not a radical skeptic.

As we turn to Bacon's *constructive* method in the *Novum organum*, the most important thing to remember, based on the considerations in this section, is that it offers a snapshot of a method that is still in flux.

5.2.2 Elimination and the First Vintage

The first step or "first job"⁵⁸ in analyzing a natural history about a given nature is the method of exclusions or of elimination. If a nature is present when the nature under investigation is absent, absent when the latter nature is present, increases when the latter nature decreases, or decreases when the latter nature increases, then it cannot be the form.

At first glance, Bacon's list of exclusions appears to fit this description.⁵⁹ Many natures are rejected "from the form of Heat" because they are not necessary conditions (i.e., because heat can be present even when the natures are not present): the Sun's rays prove that the elemental (i.e., earthy, airy, fiery, and watery) nature is not necessary for heat; campfires prove that the celestial nature is not necessary for heat; and a red hot iron proves that neither local motion nor an expansive motion (where the body as a whole expands in size) are necessary for heat since the iron is hot even when it remains motionless and does not expand beyond its original dimensions. Some natures are rejected because they are not sufficient conditions for heat (i.e., because the natures can be present while heat is not present): the lack of heat in the moon's rays proves that light is not sufficient for heat, the expansion of air with decreased air pressure proves that expansion is not

⁵⁸*N.O.* II. 19.

⁵⁹*N.O.* II. 18.

sufficient for heat, and cold air proves that thinness or a lack of density is not sufficient for heat.

However, Bacon's general description of the method of exclusion also glosses over something puzzling about these examples and their relationship to the First Vintage. Compare the excluded natures above to the First Vintage which Bacon ultimately arrives at: "Heat is an expansive motion, but restrained and struggling by way of the lesser parts. But the expansion is modified, so that in expanding all round, it nevertheless tends to rise upwards. The struggle by way of the parts is also modified, so that it is not altogether sluggish but driven on and with some vigour to it."⁶⁰ The level of specificity in this First Vintage is much greater than the level of specificity in the list of exclusions.

Here, then, is the puzzle: what is the point of ruling out such broad categories as possible definitions if the First Vintage turns out to be so specific? An analogy (and it is just an analogy) might help illustrate the problem: Suppose you choose a number between one and a hundred and give a friend twenty chances to guess it. The friend believes that his chances of guessing the number will improve with each new guess, going from a 1/100 chance, to a 1/99 chance, and so on. What your friend does not know is that the number you are thinking of is a decimal, 50.120382. His chances of guessing your number never got any better than they were on the first try because he only succeeded in ruling out whole numbers, and the class of real numbers from which you chose is infinite.

At this point it is usually said that Bacon solves the problem with what Urbach calls the principle of limited variety. We are told that Bacon believes that there are a finite number of natures in the universe (like the letters in the alphabet) and that everything involves some combination of those natures.

I agree with the standard reading that Bacon does accept this principle (and therefore disagree with Urbach's more revisionary reading, which leads him to view the First Vintage as a bold conjecture). But how many permutations of genera and differentiae are there? Bacon's *Abecedarium* lists eighty natures. Some

⁶⁰*N.O.* II. 20. Note that the instance of the red hot iron rules out a different type of expansive motion (expansion of the whole body beyond its original dimensions) than ultimately appears in the First Vintage (expansion of the lesser parts).

permutations are impossible (“expansive” is a possible differentia of “motion,” but “motion” is not a possible differentia of “expansive”), and some of the listed natures are already combinations of others, but the list of reasonable permutations must number at least in the thousands.

These considerations suggest that Bacon does not view the method of exclusions as a process of ruling out possible definitions one by one in order to converge on a small set of remaining possibilities. (Hold this thought, though. The exclusions are also related to subsequent steps of the method in that they constitute background knowledge which we must appeal to in order to interpret crucial instances and other prerogative instances properly.⁶¹) For example, a red hot iron is used to show that heat is not local motion. That example does not just rule out one definition. Because local motion is not even necessary for heat, the example shows that heat is not a limitation of local motion either. The same goes for any nature that is shown not to be a necessary condition; the instance rules out not a single definition but possibly hundreds of narrower definitions. (Returning to the analogy to guessing a number, it is as if your friend may ask you whether your number is between 21 and 22, etc.)

After the eliminative process (i.e., the list of excluded natures in II. 18), Bacon employs a roughly Aristotelian method of division in conjunction with shining instances. His use of division has, so far as I have been able to find, gone unappreciated—perhaps because he does not explicitly draw attention to this feature of his method. As the ancients used it, division was primarily a method of definition, where one starts with the genus and introduces successive divisions until one completes the process by arriving at the level of the form or species being defined. Plato used the method of division in *The Sophist* and *The Statesman* and discussed it in the *Phaedrus*, and Aristotle adopted the method as well but called for a number of reforms. There can be no doubt that Bacon has the ancient method of division in mind since he approvingly refers to the discussion of division in the *Phaedrus*.⁶²

⁶¹The best example of exclusions being used in this way is Newton’s and appears on p. 235 in 6.2.1.

⁶²“Thus, then, the special power of *Collective Instances* is great indeed, seeing that they contribute a great deal both to definitions (especially particular ones), and to the divisions or

Aristotle's reforms parallel Bacon's use of division in important ways. Those reforms include a rejection of privative divisions and the requirement that divisions be successive. (I will not discuss Aristotle's rejection of dichotomous division; suffice it to say that I view this reform as necessitated by Aristotle's application of the method to complex substances such as animals, whereas here I am concerned only with Bacon's method of defining simple natures.⁶³) In my view, these reforms are rooted in part in the assimilation of Aristotle's form-matter ontology to the method of division. That is, for Aristotle a kind is always matter relative to its subdivisions, and the subdivisions are the form that the matter takes or is shaped into (but those subdivisions can then serve as matter relative to still narrower subdivisions). Privative divisions, such as the division of animals into rational and non-rational, are thus prohibited prior to the last differentia because "not rational" cannot serve as the matter for further divisions; an absence of something cannot take on particular forms.⁶⁴ Non-successive divisions, such as the division of footed things into the horned and the not-horned, are prohibited because the divisions have to be forms of footedness (such as two-footed and four-footed). The mark of a successive division is that the differentia implies all of the kinds above it.

Bacon, in formulating his definition of heat, not only uses the method of division but proceeds in accordance with these reforms. He begins by identifying the genus of heat. Then he looks for the first differentia, which he believes to be expansiveness. Then he divides the class of expansive motion still further; heat is expansive, upward motion. Note that Bacon says that this second differentia is a modification of the first one. The third differentia is that the expansiveness is of the smaller particles, which are impeded and quiver as a result, and the fourth (again explicitly stated to be a modification of the third) is that the motion is vigorous and requires particles of a sufficient size.

Although not explicitly stated, it is rather clear that the first differentia is also a modification of the genus and that the third differentia is a modification

partitions of nature, concerning which *Plato* rightly said that *he who knows well how to define and divide, is to be counted as a god.*" *N.O.* II. 26. The reference is to 266b.

⁶³See Balme, "Aristotle's Use of Division and Differentiae": p. 73

⁶⁴"There cannot be forms of what is not." Aristotle, *On the Parts of Animals*: 642b 22-24.

of the second. Indeed, each successive differentia must be a modification of the previous one. “Modification,” I take it, is a more ontologically non-committal way of referring to the shaping of a kind into a particular form, and I think we could therefore expect that Bacon would never use non-successive or privative divisions, for reasons that mirror Aristotle’s.

To illustrate that last point, here are some putative differentia of motion which I think we can be sure Bacon would have rejected out of hand, not because they are not true of heat but because they are not modifications of motion: “necessary for life,” “useful for cooking,” “not present in empty space.”

The role of Aristotelian division in Bacon’s method of definition is important because Aristotle believes that division provides the only kind of certainty that we can expect of first principles. “But nevertheless there is no deduction in [division]; but it makes us familiar with what the thing is, if at all, in some other fashion. And this is nothing absurd; for neither, presumably, does someone who gives an induction demonstrate, but he nevertheless makes something clear.”⁶⁵ The weakness of Aristotle’s method is that it presupposes our prior acquaintance with natural kinds and their properties. (Aristotle himself emphasises the risk of begging the question if one thinks that the method of division can demonstrate the definition). If we have that acquaintance (through induction), then division is a good tool for arriving at definitions that capture the similarities and differences that exist in nature.

Bacon’s use of division similarly presupposes that the hierarchy of notions that he employs is justified. If the notion of ‘expansiveness’ turns out to be confused, then the resulting definition of “motion” will be confused as well. That said, in Bacon’s hands, division is a powerful tool because the processes of enhancement and self-correction discussed in Chapter 4 help to explain how the requisite notions can become increasingly justified over time.

The other tool that Bacon employs in conjunction with the method of division is the shining instance. Shining instances⁶⁶ are instances in which either the formal cause or (as the examples below will make clear) an important part of

⁶⁵Aristotle, *Complete Works of Aristotle: Posterior Analytics*, 91b.

⁶⁶See A.1.2.2: p. 255.

the formal cause stands out. Two facts explain the existence of shining instances: first, that natures never exist by themselves but are always compounded together in bodies, and second, that any nature can be present in varying degrees. These facts make it possible for a nature that belongs to the form either to stand out to us or to be harder to detect. If the other natures that are compounded with the formal cause of the nature being investigated mask that form, it will be harder to detect; if not, it will be easier. If the nature that is the form is present in a lesser degree, the form will be harder to detect; if in a greater degree, easier.

Shining instances “readily lead you to differences,” i.e., to one or more of the differentiae in the definition of the form.⁶⁷ Not all of the differentiae need to be manifest. For example, in II. 24 Bacon says that “air in a calendar glass” (by which he means to refer to an air thermoscope)⁶⁸ is a good shining instance of the expansive motion of heat (expansiveness being the first differentia in the First Vintage that precedes this aphorism). Note that Bacon regards fire and boiling water as poorer shining instances since, although they display the genus and first differentia of heat, we lose track of that motion at the edge of the flame or at the boundary between water and vapor, making the expansiveness of the motion a little less evident.

That, at least, is the theoretical account that Bacon offers of shining instances. In practice, Bacon is not very picky in selecting shining instances. The official account in II. 24 dismisses flame and boiling water as inferior shining instances, but Bacon uses boiling liquids as a shining instance of the expansiveness

⁶⁷*N.O.* II. 25.

⁶⁸The air thermoscope would probably have resembled the one built by Galileo in 1603 and described by Castelli in 1638: “I remembered an experiment showed to me already more than thirty-five years ago by our Lord Galileo, which was that, taken a small decanter of glass with the size of a small chicken egg, and a neck about two spans long and as thin as a grain stalk, and once the mentioned small decanter was well heated by means of the palms of the hands, he turned it upside down with its mouth into a vase placed below, where there was a bit of water. By making the small decanter free from the heat of his hands, the water immediately started ascending along the neck and went over the level of the water of the vase for more than one span; that effect then was used by the same Lord Galileo to build an instrument to examine the degrees of heat and cold.” So heat causes the air in the flask to expand, thereby pushing the water back down into the vessel. When the air cools and contracts again, the water rises. The translation of Castelli’s letter appears in Valleriani, *Galileo Engineer (Boston Studies in the Philosophy of Science)*: p. 161.

of heat in II. 20. Furthermore, II. 20 uses shining instances that point to the *genus* of heat (flame and boiling liquids being among the examples here as well), whereas the official account of shining instances in II. 24 suggests that they must be used for discovering the differentiae and II. 25 suggests that clandestine instances are the ones to turn to for help in discovering the genus. There is an easy way to resolve this apparent tension, though. Bacon sees shining instances that exhibit the whole form (including all of the differentiae) as the best or the prototypical shining instances, but he is willing to make more flexible use of inferior shining instances, which exhibit only part of the form, in practice.

Bacon regards shining instances as useful in discovering the First Vintage, and they guide him in using the method of division. He implicitly relies on them at every step of the way when defining heat. Alluding to one of his other terms for shining instances—namely, indicative instances—he says that the genus of heat (motion) is *indicated* [*ostenditur*] most clearly in flame.⁶⁹ He says that the first among the differentia is expansiveness, and that this is indicated [*ostenditur*] by boiling liquors, among other things. He continues to use shining or indicative instances to support his claims about all of the remaining differentiae as well. In some cases, they serve the role of contrast classes. For example, Bacon uses the instance of a red hot iron, which shows that expansiveness of the whole body is not necessary for heat to be present, to support his claim that the expansiveness present in heat involves the smallest particles. (I take it that this is another way of putting Bacon’s point that shining instances help identify differences.)

Shining instances are useful in guiding the process of division, then. But they are dangerous if we fail to seek stronger sources of justification. “Yet we must attach a warning to these same instances and stop the intellect running away with us. For whatever shows off the form and shoves it forward apparently to meet the intellect head on, should be regarded with suspicion, and demand recourse to a strict and careful *Exclusive* process.”⁷⁰ This warning is noteworthy for two reasons. First, it implies that shining instances are not the ones to focus on if our interest is in Bacon’s account of certainty. And second, it shows that both Urbach and

⁶⁹N.O. II. 20: 2A4^V.

⁷⁰N.O. II. 24.

McCaskey underemphasize the importance of the exclusive process to Bacon (we can continue with that process either by going back to the table of exclusions or by using the prerogative instances that have an eliminative function). Elimination plays an important (but not all-important) role in Bacon's quest for certainty.

5.2.3 Prerogative Instances

Once one has a First Vintage, one can turn (or return, perhaps one should say, since some of them are supposed to be employed in the construction of a natural history) to the prerogative instances, which (like tools in a toolbox) can be applied in just about any order. Relevant here are those which make available new information to the intellect (as opposed to those which make available new information to sense-perception or that have an operative purpose rather than an informative one, which are more relevant at the natural historical stage). Bacon's own taxonomy of the instances is reflected in the appendix to the dissertation.⁷¹ Here I will break down the instances informative to the intellect according to the kind of help they offer in further refining and justifying the First Vintage:

1. Some of the prerogative instances support (with varying degrees of justification) narrowing the range of possible definitions to a finite domain. These include migratory instances and shining instances.
2. Many of them are aids to the continued application of the method of collection and division. Dividing nature at the joints can also involve broadening or narrowing the definition to better capture the evolving tables of instances.
3. Some of the prerogative instances assist in the continued process of eliminating candidate formal causes. These include solitary instances and crucial instances. However, since there is another kind of crucial instance which is non-eliminative, I will devote a full section to crucial instances after discussing the other prerogative instances.

⁷¹Incidentally, it may be helpful to read the appendix in its entirety before continuing.

Those that narrow the definition to a finite domain If the eliminative element in Bacon's method is going to be of much use, then Bacon must have some way of justifying either a disjunctive premise which sets out the possible definitions, or—what is probably more feasible and what Bacon probably has in mind (especially given what I said above about how aspects of Bacon's employment of the method of exclusions cannot be formalized as a disjunctive syllogism)—a general characterization of a space of possibilities that is limited enough to be thoroughly explored. This, I argue, is one of the functions of both migratory instances and shining instances.

Migratory instances

are the ones in which the nature under investigation migrates toward generation when previously it did not exist, or conversely migrates towards corruption when previously it did. Thus in either journey such instances are always twinned, or rather one instance in motion or transition is carried towards its opposite extreme. Instances of this kind not only accelerate or strengthen the *Exclusive* process, they also drive the *Affirmative* or very form into a corner.⁷²

The pattern of migratory instances is this: One looks for instances where the nature under investigation is either generated or destroyed by some efficient cause. These instances are “twinned” because they involve one instance where the nature under investigation is present as well as one instance where it is absent. Those two instances taken together make up a single migratory instance, and they tell us that the formal cause of the nature must be among the conditions introduced or destroyed by the efficient cause.

Migratory instances “accelerate” the exclusive process because they exclude many candidate definitions at once. They can also “strengthen” or further justify exclusions that one was already inclined to make. But more important than this negative, eliminative role is their positive role in ruling in a finite range of forms.

Bacon's example is the nature of *whiteness*. Pair the instance of water, from the table of absence, with the instance of frothy water, from the table of presence. We now know that the formal cause of whiteness is something that

⁷²*N.O.* II. 23.

is introduced by the frothing process. This may not give us an explicit list of possible formal causes to be used as a premise in a disjunctive syllogism. As Bacon observes, much depends on how simple the migration is, and it seems to me that much also depends on how much background knowledge we have about the instances and processes in question. But even if we cannot justify an explicit list, we can narrow the search for the formal cause to a limited domain—the domain of natures introduced by frothing. If one already has a First Vintage, then one should be able to use migratory instances to correct it, to narrow it down further, or to corroborate it.

Shining instances can have a similar function since they can narrow the formal cause to one that falls under a particular genus. However, since they typically do so with a degree of justification that Bacon acknowledges to be weak, I will not discuss them further here.

Aids to Collection and Division I have already discussed the role of the method of division in framing the First Vintage. The method of division returns, along with the companion process of collection, among the prerogative instances, and again the purpose is to help ensure that notions carve the world up in a way that corresponds to real similarities and differences among the instances. The following instances all relate in one way or another to the attempt to divide nature at the joints: constitutive instances,⁷³ instances of alliance,⁷⁴ subjunctive instances,⁷⁵ monadic instances,⁷⁶ deviating instances,⁷⁷ and clandestine instances.⁷⁸ I will select the first three of these for discussion here, but all of them are summarized in the appendix.

Constitutive instances correspond to the process of collection. Bacon explicitly invokes the *Phaedrus*, where collection is characterized as a companion process to division that involves gathering similar things together into kinds. In

⁷³A.1.2.2: p. 256.

⁷⁴A.1.2.2: p. 257.

⁷⁵A.1.2.2: p. 257.

⁷⁶A.1.2.1: p. 253.

⁷⁷A.1.2.1: p. 253.

⁷⁸A.1.2.2: p. 256.

constitutive instances, these kinds are species that are more general than the items on the table of presence but more specific than the nature being defined. One of Bacon's examples concerns the nature of *memory-aids* (a suggestive example, since constitutive instances mitigate the need to remember the lengthy table of presence). The table of presence for this nature would include an assortment of diverse memory-aids. Using constitutive instances involves searching the table for types of instances that make up mid-level kinds. For example, patterns, artificial places, and poetic verse all belong to a species that Bacon labels "the cutting off of infinity"⁷⁹ since they all provide some clue that can narrow the search for the thing to be remembered, while things learned during childhood, thought about before sleep, and that happen for the first time all belong to another species labeled "impression on a clear mind"⁸⁰ since the ease with which they are remembered has to do with the state of mind one is in when the memory is formed.

Constitutive instances are useful, according to Bacon, because "whatever unites nature, though by imperfect means, paves the way to the discovery of forms."⁸¹ It is important to observe that their role is non-discursive. They are useful because it is easier to identify (and to be justified in thinking that one has successfully identified) what a handful of closely related items have in common than it is to identify what the dozens or hundreds of items in the table of presence have in common.

Another aid to collection is the instance of alliance. Instances of alliance are invoked when the table of presence initially fails to gather together some of the instances of the nature on account of the false belief that they belonged to a separate kind. For example, one might initially leave the heat of the sun off the table concerning heat on the grounds that celestial heat must be of a different nature than terrestrial heat. An instance of alliance is an experiment that exhibits the similarity in nature between celestial and terrestrial heat, thereby allowing us to add instances to our tables and work towards broadening our definition. So again, these instances are part of the project of trying to capture the real divisions

⁷⁹*N.O.* II. 26.

⁸⁰*Ibid.*

⁸¹*Ibid.*

among natural kinds.

Subjunctive instances (which were first discussed on p. 114 in 4.3.3) also have a broadening function. These are instances where the nature being investigated is present to a maximal or minimal degree. They thus help to ensure that the full range of cases is represented in the tables and thereby “point quite openly to the real dividing lines of nature.”⁸²

All of these instances are important in offering a response to the worries about extrapolation discussed at the start of the chapter since they offer grounds for increased or decreased certainty in our belief that we have genuinely latched onto a single type of phenomenon. If it is a single type, then it should be expected to have a single formal cause that applies to all the instances.

Aids to Elimination Some of the prerogative instances further the elimination of natures in distinctive ways. Although their purpose is no different than that of the original table of exclusions—to rule out possible definitions in order to hone in on a provisional interpretation of the form—these prerogative instances generally accomplish this eliminative work more effectively. Again, the idea is not that we will rule out every possible explanation but one, but that if we can rule out a great many possible explanations, then the non-eliminative instances (such as migratory instances and crucial instances) will be able to use those exclusions as background knowledge.

The examples I will focus on are solitary instances and crucial instances. The latter are especially important in the quest for epistemic certainty, and I will discuss them in detail in the next section.

Solitary instances have the function of speeding up the eliminative process—that is, of eliminating many candidate natures from the definition simultaneously—and of strengthening or providing further justification for prior acts of elimination that may not have been conclusive.

There are two kinds of solitary instance: those which have a solitary resemblance and those which have a solitary discrepancy. The former kind takes two

⁸²*N.O.* II. 34.

items from the table of instances that have the nature being investigated, where the only nature those instances have in common is the nature being investigated. Bacon's description makes it sound as if it has the following form:

(5.2)

(1) Kind of body with properties A, B, and C has Nature N.

(2) Kind of body with properties D, E, and F has Nature N.

∴ (3) Neither A, B, C, D, E, nor F are the cause of N.

There is something a little puzzling here, though. If indeed the first instance and the second instance have the same nature in common, then they *must* have at least one additional nature in common—the formal cause. For example, two instances could not both have the nature of heat unless they also exhibited some kind of motion.

The usual fix is to interpret this type of solitary instance as akin to Mill's method of agreement, an interpretation which would presumably look as follows:

(5.3)

(1) Kind of body with properties A, B, and C has Nature N.

(2) Kind of body with properties C, D, and E has Nature N.

∴ (3) Neither A, B, D, nor E are the cause of N.

C, or a modification of C, is the cause of N.

Bacon's claim that the instances have *only* nature N in common could be attributed to the fact that N is in fact identical to C, or to a modification of C, so that there is no distinct second nature shared by the instances.

As tidy as this interpretation is, it just doesn't fit Bacon's example:

For example, if you are investigating the nature of *Colour*, *Solitary Instances* are prisms, clear gems which show colours not just inside themselves but outside on a wall, dew too, etc. For these have nothing in common with the fixed colours of flowers, coloured gems, metals, wood, etc., besides colour itself. From this we easily see that in the first group colour is nothing other than a modification of the image of light sent out and received by the different angles of incidence, whereas in the second it arises from the textures and schematisms of the various bodies.⁸³

The conclusion seems to be that color sometimes has one formal cause and sometimes has another, which is in effect to deny that there is a single nature N involved. Or to put it another way, Bacon seems to suggest that the modificationist theory of color is true in one domain and false in another. Another problem is that it just seems false that the solitary instances in the example—the colors produced by the refraction of white light through clear gems and those produced when white light is reflected from opaque gems, to take one pair of examples—have nothing in common except color and its formal cause. They are both caused by gems, after all.

Bacon is not at his clearest in this passage, but we have a couple of interpretative options. We can follow the usual interpretation and view solitary instances as akin to Mill's method of agreement—at the cost of asserting that Bacon provides an ill-conceived example. Alternatively, and this is my reading, we might think that Bacon's example omits the conclusion. Perhaps the conclusion implicit in the example is that any proposed formal cause which is incompatible with *either* modificationism in the case of refraction or the textural explanation in the case of reflection is to be ruled out (with some unspecified degree of certainty). This is an interesting possibility because the acceleration of the exclusions is mediated by two causal accounts that apply to two of the species of the form but not to the form as a whole. This reading is in keeping with the spirit of migratory instances as abstractly described: radically different instances are chosen in order to accelerate and strengthen the process of elimination. However, the example shows that the temptation to provide a universal schema for solitary instances may be misguided.

⁸³N.O. II. 22.

The other kind of solitary instance is usually interpreted as akin to Mill's method of difference:

(5.4)

- (1) Kind of body with properties A, B, C, and D (where D is not a distinct nature from N) has nature N.
- (2) Kind of body with properties A, B, C, lacks nature N.

∴ (3) Therefore, neither A, B, nor C are the cause of N

But again, Bacon's example doesn't fit.

For the black and white of marble, and the white and ruddy spots of clove-gillyflower agree in pretty well everything except the colour. From this we easily see that colour has little to do with the intrinsic natures of any body, but only resides in the grosser and so to speak mechanical arrangement of the parts.⁸⁴

Since the desired conclusion pertains to the cause of color, Mill's method of difference would have called for one instance that has color and one instance that lacks color, whereas the example includes two instances that are both colored but which merely have different colors. Furthermore, the conclusion stated in the example refers to a cause that is present in both instances, whereas the method of difference would require us to look for something that is absent in one of the instances.

The only way I can make sense of the example is to say that Bacon is inquiring not into the cause of color as such but into the cause of a thing's having the particular color it has. In that case, the example is still broadly compatible with Mill's method of difference.

Before turning to crucial instances, let us review where we stand in providing further justification for the First Vintage. The method of elimination has already been enhanced and augmented in ways that contribute to the justification

⁸⁴Ibid.

of conclusions about formal causes. Migratory instances, we have seen, may sometimes rule *in* a finite range of natures as possible causes, and even if we are not able to list every possible nature, it is plausible that we might have an awareness of a space of possibilities that can be fully explored. Although Bacon does not say so explicitly, it is possible that he thinks that migratory instances, in conjunction with a list of exclusions, might in some cases provide us with certainty about a formal cause.⁸⁵ We have also seen the importance of the search for natural kinds. The prerogative instances that relate to that search can add to our justification in believing that whatever is common and distinctive to the observed instances of a nature will be shared by the unobserved instances as well. Finally, even where the method of elimination makes a return, it does not do so in quite so feeble a manner as at first. Although there is some confusion about how exactly solitary instances are supposed to work, it is clear that they are intended to accelerate and strengthen the process of elimination. And now we come to crucial instances, which sometimes augment the process of elimination as well, but which can sometimes go well beyond this function.

5.3 Crucial Instances

Although it would be wrong to think that crucial instances are supposed to prove definitions with certainty in every case (as Bacon allows for their having varying degrees of exactness and says that some are better than others), Bacon does say that the interpretation of nature is *sometimes* completed with them—and they are the only prerogative instance about which he says this. Indeed, he

⁸⁵Migratory instances rule in a finite range of forms, so if we can exclude everything within that range except for one definition, then we are finished. Or perhaps more realistically, if we can exclude everything within that range except one genus, then we can be certain we have the genus, even if more differentiae are still necessary to specify the complete formal cause. Here is an analogy. Suppose the police see a murder suspect run into a house. They surround the house and seal off all of the exits (suppose they know where all of the exits are and have all the other necessary background knowledge), so they know that the suspect is somewhere inside. When they search a room thoroughly, they can exclude it. Suppose that, at the end of the search, there is just one room left, and it is locked. Even if they cannot get inside to confirm that the suspect is there, they can know that he is inside by using their knowledge of the relevant search area together with the list of excluded rooms.

explicitly contrasts crucial instances with “probabilistic reasoning” and frequently uses certainty language throughout his examples.⁸⁶

In this section, I will begin in 5.3.1 with Bacon’s abstract account of crucial instances and make some general observations about how that account relates to the examples that follow. Then in 5.3.2 I will lay out three of Bacon’s most ambitious examples of crucial instances. The rest of the section will elicit from the examples some further observations regarding crucial instances. In 5.3.3, I will discuss the role of background knowledge in interpreting the instances and offer a Baconian response to arguments for underdetermination rooted in holism. In 5.3.4, I will discuss how Bacon might intend to establish the exhaustiveness of the alternatives and relate his efforts to arguments for underdetermination rooted in the difficulty of justifying such a disjunctive premise. And finally in 5.3.5, I will argue that Bacon believes that some crucial instances offer direct and conclusive evidence of the cause of a nature and that in such cases the other alternatives do not need to be falsified as part of the process—although their falsity follows, as a matter of course, once the true cause is discovered.

5.3.1 General Observations about Crucial Instances

The general pattern of crucial instances—which are so-called not because they are crucially important, but because they help point the way like signposts [*cruces*]⁸⁷ when one is at a crossroads—is as follows:

when in the investigation of any nature the intellect is finely balanced, and so that it is uncertain as to which of two or sometimes more natures the cause of the nature under investigation should be attributed or assigned (on account of the frequent and normal concurrence of many natures), *Crucial Instances* indicate that the partnership of one of the natures is (in relation to the nature under investigation) constant and indissoluble, while that of another is variable and separable—whence the question is settled, and the former nature is accepted as the cause while the other is set aside and rejected.⁸⁸

⁸⁶ “*rationes probabiles*,” *N.O.* II. 36: 2I3^r 10.

⁸⁷ *N.O.* II. 36: 2G3^v 29.

⁸⁸ *Ibid.*: 2G3^v 32 - 2G4^r 6.

One initial observation is that Urbach is wrong to claim that crucial instances abandon the analysis of bodies into simple natures and instead involve the choice between hypotheses. The abstract description above, as well as Bacon's examples of crucial instances that follow, are in agreement on this point. Each example is introduced with the call to "let the nature under investigation be [*sit Natura Inquisita*]" such-and-such.⁸⁹ Of course, one could use modern terminology, as occasionally I will, and say that the conclusion drawn in each case is that a particular hypothesis is confirmed—but these are still hypotheses *about* the causes of natures.

The abstract description does not correspond to every example that follows it (not all of them settle "the question," as I will discuss in a moment), but it is still worth noting that Bacon does not say that crucial instances work by means of falsification. It sounds instead as if the falsification of the wrong hypothesis and the confirmation of the correct hypothesis happen simultaneously. But we will have to turn to Bacon's examples to make more sense of why that might be the case.

Note also that Bacon states that the need for crucial instances arises from a particular problem, "the frequent and normal concurrence of many natures." I take this to mean that two natures—such as the nature of earthly rotation and the nature of cosmic rotation—would often (if instantiated) produce many of the same effects. Sometimes all of our currently known instances are compatible with either of two or more natures being the cause. Crucial instances help resolve deadlocks of this kind.

But they do not always do so with certainty. On this point, Ian Hacking has it right: "Later philosophy of science made crucial experiments absolutely decisive. The picture is that two theories are in competition, and then one single test conclusively favours one theory at the expense of the other. Even if the victorious theory is not proved true, at least the rival is knocked out of action. That is *not* what Bacon says about instances of the fingerposts."⁹⁰ In fact, a survey of Ba-

⁸⁹Ibid.: 2G4^r 12, 2H1^r 27, 2H2^r 31, 2H2^v 10, 2H3^v 1, 2H3^v 24, 2H4^r 21, 2I1^r 11, 2I1^r 31, 2I2^v 6.

⁹⁰Hacking, *Representing and Intervening: Introductory topics in the philosophy of natural science*: pp. 249-50.

con's ten examples reveals *two* important distinctions among the crucial instances: first, whether they purport to establish a conclusion with certainty; and second, whether they point uniquely to one nature as the cause or merely (if there are three or more alternatives) rule a single cause out, leaving the choice between the remaining alternatives undetermined. These last crucial instances do not purport to establish anything affirmatively but only negatively.

Here, very briefly, are some examples of each kind, although I will quickly turn my attention to the most ambitious variety, the kind of crucial instance that aims to establish with certainty and affirmatively what the cause of a nature is. (Bacon provides no examples of merely negative and probable crucial instances, and it seems possible to me that such examples would not be important enough to qualify as prerogative instances at all. For that reason, I omit this category.)

Certain and affirmative crucial instances I will summarize the examples for now and return to them for a fuller examination in the next subsection: (a) Tides are caused by either a side-to-side or an up-and-down motion. Information about the time of high tide at various key points around the globe could be used to falsify one account of the cause and affirm the other. (b) The diurnal motion is caused by either terrestrial or heavenly rotation. Information about the (in our terms) linear velocity of objects at key points on the earth and in the heavens can be used to falsify the Copernican account and affirm that the whole cosmos participates in the diurnal motion. (c) Weight is caused by either a non-relational property of the heavy object or an attractive force exerted by the Earth. Information about the weight of objects at various elevations (gathered through an experiment involving two different types of clocks) can be used to falsify the account which states that weight is a non-relational property and confirm that it is caused by the attractive force of the Earth. (d) The transitory nature of flame is caused by either the cessation of the cause of the flame (such as the removal of a fuel source) or by the antagonistic force of the air. If a flame that it is shielded from the air by a surrounding flame does not go out but instead takes on a spherical shape, then the antagonistic force of the air must be the cause of the transitory nature of flame.

A certain but merely negative crucial instance The rising and falling motion of the tides (this assumes that one has already established that the motion of the tides is an up-and-down rather than side-to-side one) is caused either by an attractive force that pulls up on the sea, the expansion of a fixed mass of water, or the inflow of additional water from beneath the ocean. If an attractive force pulls up on the sea, it must pull up on the middle (otherwise, by pulling up on the sides at regular intervals, it would create a side-to-side motion rather than a rising and falling one). Therefore, if one finds that it is false that water bulges in the middle of the sea at the same time as low tide on two opposite shores, then this “magnetic” account is falsified with certainty. However, two other possible causes remain, such that the crucial instance has not established the cause affirmatively.

A probable and affirmative crucial instance The transitory nature of flame is caused either by the removal of the cause or by the antagonistic force of the air. The shape of a flame (broader at the base and narrower at the tip) indicates that air is antagonistic to flame, for the more time the air has to interact with the flame as it proceeds upwards, the narrower the flame becomes. Bacon says that his other crucial instance concerning flame is a more exact one (*accuratior*), implying that this one is not quite certain.

5.3.2 Examples of Certain, Affirmative Crucial Instances

Let us turn our attention to the first kind of crucial instance. Bacon’s first example concerns the nature of the tidal motion. He lists two possible kinds of cause: a side-to-side, progressive motion or an up-and-down, rising and falling motion. (A progressive motion is like the motion of water in a bowl when one tilts it from side to side—the water falls on one side while it rises on the other. Rising motions involve either expansion of a constant mass, vertical locomotion, or an increase in mass from another place.) If the motion of the tides is progressive, then a rise on one shore must be compensated for by a fall in water level on some other shore. On the other hand, if the motion is vertical then a high tide on one shore should be roughly simultaneous with a high tide on an opposite shore, and

a low tide with a low tide. Bacon confirms that this is so by examining each species of vertical motion. Suppose, for example, that the tidal motion is vertical *locomotion* caused by an attractive force pulling up on the middle of the sea. Since there can be, Bacon assumes, no vacuum, water would have to flow from opposite shores to the middle of the sea, resulting in simultaneous low tides on the opposite shores.

This reasoning leads to the crucial instance, which in fact consists in a *set* of observations detailing the times of high tide and low tide at various key points around the world. If one selects key points that have nearly simultaneous high tides and finds that there is no outside source that could be supplying the water to both simultaneously, then the motion has to be a rising one.

The selection of key points on opposite sides of the Atlantic would not be sufficient. For example, simultaneous high tides in Florida and Spain do not decide the matter, according to Bacon, because the Atlantic Ocean is narrow enough that it might behave like a river, with water coming from the Indian Ocean, passing to the south of Africa, and then flooding into the space between North America and Europe so that the opposite shores have simultaneous high tides.

But if there were two more simultaneous high tides, one on the Pacific side of the Isthmus of Panama and one on the eastern side of China, then there is no body of water remaining to supply all of the additional water, and the tidal motion would have to be a rising one rather than a progressive one. The South Pacific is much wider than the Atlantic, and the passage south of South America is much narrower than the passage south of Africa, such that a sufficiently vast quantity of water could not enter the Pacific basin quickly enough to make the opposite shores flood simultaneously.

Another crucial instance deals with the nature of the diurnal motion. Two possible causes are considered, the rotation of the Earth and the rotation of the heavens. Bacon's characterization of this second option is a departure from the traditional Aristotelian-Ptolemaic model, however. He instead has in mind what he calls a cosmical motion, which he defines in the *Thema Cæli* as one which "the heavenly bodies receive by consent not of the heavenly bodies alone but of

the whole universe.”⁹¹ The notion of “consent” plays an interesting role here. The idea is that everything in the universe, from the stars and planets to the winds and from the oceans to compass needles, participates in a single daily motion from east to west. Bacon does not have in mind a motion that penetrates from the outside in. That would be an example of what he calls mutual motion (*ad invicem*), which is motion that is communicated from one particular thing to another. Instead, everything has an impulse to rotate of its own accord or spontaneously, and it is because everything in the universe has this common nature that the diurnal motion exists.

The crucial instance in this case again involves plotting the motion of objects at various key points—but this time, those key points need to be spread out at various distances from the earth (and depths below the earth) and at various terrestrial and celestial longitudes and latitudes.⁹² If everything shares in the same east-west motion, then the motion is a cosmical one. One might object that a motion could be communicated from the outside in and give rise to the same motions. There is evidence in the *Historia ventorum* that Bacon recognizes this complication since he seeks additional crucial instances to rule out the possibility that the sun causes the winds by heating the air, which would make this motion *ad invicem*.⁹³

Let us take a look at one more example, which deals with the cause of the fleeting nature of flame. Again, two possible causes are considered: “this fleeting nature either happens when the cause that first produced it stops, as in lumen,

⁹¹Bacon, *Philosophical Studies*, c. 1611- c. 1619: G10^r.

⁹²This is based on a reading of the instance that is unsympathetic to Bacon as a scientist since (in order to determine velocities for celestial objects that are not merely relative to the Earth) he would have to beg the question by assuming that the earth is at rest. One might try to say, on an alternative reading, that Bacon does not beg the question and that the observational data required for the instance includes only relative motion. Then one might have an inference to the best explanation—the idea being that the orderly arrangement of relative speeds that Bacon expects is best explained by means of a cosmic motion that everything participates in. After all, even though the Copernican theory could explain the celestial motions, it offers no good explanation if (as Bacon expects) the tides and the winds share in the diurnal motion as well. I think my reading of this crucial instance is more likely. It is more in keeping with Bacon’s way of speaking since he talks as if the motions to be used are absolute. And it would be odd for Bacon to put so much weight on what would otherwise amount to an argument from simplicity since Bacon typically cautions against assuming that the simplest explanations are best.

⁹³Bacon, *The Instauration magna: Part III: Historia naturalis*: E5^v-E6^v.

sounds, and (as they call them) violent motions, or because flame is by nature capable of persisting but here with us suffers the force of ambient contrary natures which destroys it.”⁹⁴ After describing an initial, merely probable crucial instance that argues in favor of the latter option, he turns to what he considers a still better crucial instance that involves shielding one flame from the ambient air by means of another flame. Bacon pours spirit of wine (distilled brandy) into a bowl and sets a candle in the middle. He reports that the flame from the brandy will surround the candle flame, but that the two can still be distinguished because the flame from the brandy has a bluer hue. Bacon reasons that if the fleetingness of flame is caused by the hostile action of the ambient air, then the candle flame, which is now shielded from the air by another, kindred flame should no longer be fleeting. Instead of taking the form of a pyramid—wider at the base and narrowing at the top as the air has more and more time to press in on it—the flame should, Bacon thinks, take the form of a globe. If it does, then the second of the two causes Bacon initially mentions must be the correct one.

5.3.3 The Reliance on Background Knowledge and Auxiliary Assumptions

Bacon relies on quite a bit of background knowledge in these crucial instances, some of it explicitly and some of it implicitly. Indeed, the typical relationship between exclusions and First Vintages on the one hand—I mean to include both those within the current inquiry as well as those from other inquiries—and crucial instances on the other is that the former serve as background knowledge in seeking, identifying, and interpreting the latter. For example, Bacon often seeks crucial instances in order to confirm a provisional interpretation that he already has, and his list of the possible explanations may be partly informed by a process of exclusions that has already eliminated other candidates. (Bacon does not say one *has* to hook crucial instances up with exclusions in this way, but he provides the tools to do so, and we will see Newton work this way on p. 235 in 6.2.1.)

I now want to argue that Bacon is aware of the role of background knowledge

⁹⁴*N.O.* II. 36: 2I2^v.

and has reasons for thinking that the reliance on background knowledge does not threaten the certainty of crucial instances, as some arguments for the problem of underdetermination charge. Consider some implicit assumptions in the first crucial instance concerning the tides. Background knowledge about the winds (deriving from a separate inquiry into their nature) explains why he might not consider the possibility that wind could blow water towards Europe at the same time as it blows water towards the Americas, which would allow a progressive motion to give rise to the effects that he expects if the motion is up-and-down.. As he makes clear in the *De fluxu*, winds can produce smaller variations in the motion of the sea, the currents, but they cannot explain motions as sizable and as regularly patterned as the tides.

He also has to rely on geographical knowledge, which itself presupposes prior knowledge from other inquiries. For example, we might need to know that the continents do not drift so quickly as to invalidate our maps from one day or year to the next.

Bacon explicitly assumes in this crucial instance that the earth is motionless and states that if the earth does move (either with its own proper motion, as the Copernican theory states, or with a motion that participates in the general cosmical motion) then a progressive motion might be able to explain simultaneous high tides at all the key points. This point is important because it shows that crucial instances can establish conclusions that are conditional on the results of inquiries into other natures. This crucial instance establishes with certainty that *if* the earth is motionless, then the tidal motion is a rising and falling one. Bacon himself does not think that the antecedent of this conditional holds true (for he believes that the tidal motion is progressive and is caused by the participation of the tides in the diurnal motion), yet he still uses this as an example of a crucial instance.

The goal, of course, is the knowledge of natures, not of conditional propositions. But this sort of modularity—in which we push our inquiry into one nature to the fullest extent possible and await further information from other related inquiries—is intended to be a means to that goal. If, at some point during the

inquiry into the nature of the diurnal motion, one establishes with certainty that the earth is motionless, then one can return to the inquiry concerning the tidal motion and simply remove the conditional.

Holist arguments for underdetermination, which one finds exhibited in Duhem's objections to the possibility of crucial experiments, are very much related to all of this reliance on background knowledge. Suppose we gather the information about the tides and find that high tide is simultaneous at all of the necessary key points. The Duhemian concern is that we have not simply falsified the hypothesis that tides are caused by a progressive motion, but that we have falsified the conjunction consisting of that hypothesis and every other required belief. The crucial instance thus tells us that *either* the tidal motion is not progressive *or* the earth is not motionless *or* our maps are not accurate, etc.

Bacon's response would be to question why we cannot establish each of the assumptions with certainty. He demonstrates a sensitivity to this issue in his adoption of the practice of linking different inquiries with each other. In his Latin natural histories, he often uses the label "*connexio*" to indicate that other inquiries should be brought to bear on the current one,⁹⁵ and in the *De fluxu* he uses the heading "*Syzigiae*," or conjunction, for the same purpose.⁹⁶ Bacon also describes the importance of stating such links in the *Abecedarium*: "I interpose connections and links to stop the inquiries being too abrupt."⁹⁷ "Abrupt" is Rees' possibly overly literal translation of the Latin *abruptae*, which is probably better translated as "separated" or "disjointed" in this context.

Here the account of Bacon as a foundationalist in Chapter 4 takes on additional importance. A crucial instance can only establish an affirmative conclusion with certainty if all of the auxiliaries are lower down in the hierarchy of abstraction are themselves known to be true. I do not know of a way to establish with abstract argumentation alone that we are ever in that situation, but it is in part to that end that I will consider examples of crucial instances from the history of science in the next chapter.

⁹⁵See, for example, the *Historia ventorum*, where this practice is so frequent that one can flip to almost any page and find the bolded label. ff

⁹⁶Bacon, *Philosophical Studies*, c. 1611- c. 1619: I8^r.

⁹⁷Bacon, *The Instauration magna: Last Writings*: 37^r 25.

5.3.4 The Exhaustiveness of the Alternatives

Duhem himself recognized that the foundationalist defense of crucial experiments above was to be expected. But he did not think that his next objection—which has been called the problem of contrastive underdetermination—was so easily answered.⁹⁸ It is worth quoting Duhem here since, in this passage, he might as well be addressing Bacon directly:

But let us admit for a moment that in each of these systems [concerning the nature of light] everything is compelled to be necessary by strict logic, except a single hypothesis; consequently, let us admit that the facts, in condemning one of the two systems, condemn once and for all the single doubtful assumption it contains. Does it follow that we can find in the crucial experiment an irrefutable procedure for transforming one of the two hypotheses before us into a demonstrated truth? Between two contradictory theorems of geometry there is no room for a third judgment; if one is false, the other is necessarily true. Do two hypotheses in physics ever constitute such a strict dilemma? Shall we ever dare to assert that no other hypothesis is imaginable? Light may be a swarm of projectiles, or it may be a vibratory motion whose waves are propagated in a medium; is it forbidden to be anything else at all?⁹⁹

This objection raises three questions for Bacon. First, does he think that we need to be certain that we have exhausted the possible alternatives, if the conclusion is to be certain? Second, does he think that we *can* exhaust the possible alternatives, and know that we have done so? And third, if he does think that we can do so, *how* does he think this is to be accomplished? My view, very briefly, is that Bacon thinks that we can know that we have exhausted the alternatives by relying on our background knowledge, but that the exhaustion of the alternatives is not ultimately very important because Bacon aims for crucial instances that are non-eliminative in nature.

My answer to the first question is that Bacon does not think that crucial instances always need to exhaust the alternatives in order to allow us to draw a conclusion with certainty. I will explain why in 5.3.5, but in short it is because

⁹⁸For example, that label for the problem is used in Chernoff, “The Impact of Duhemian Principles on Social Science Testing and Progress”: p. 231.

⁹⁹Duhem, *The Aim and Structure of Physical Theory*: p. 189.

crucial instances are not intended (as Duhem imagines) to proceed by means of falsifying the incorrect hypotheses but rather by means of directly affirming the correct hypotheses. False hypotheses, including any that have as yet been unconceived, are then falsified as a matter of course because they conflict with the conclusion.

But even though exhausting the alternatives may not always be necessary, Bacon does believe it possible. In listing the alternatives at the start of each example, he often says that the list is necessary—‘*necesse est*.’ The tides are one such example. It is necessary, he says, that the motion is either progressive or up-and-down.

Then how does Bacon justify this certainty that the cause is among the alternatives listed? He must rely on prior knowledge of the natures described in each alternative, gathered—not *a priori*, as Jardine claims—but *a posteriori* from the inquiries into those other natures. In other words, he again relies on background knowledge, and the viability of his foundationalism will again determine whether he can succeed.

The example concerning the tides offers one of the most compelling alternatives. Knowledge of those alternatives, if we have it, must derive from the inquiry into “the paths of motion,” one of the natures listed in the *Abecedarium*. Note that the two alternatives in this example are possible *genera* of the tides, and this helps subsume *many* possible formal causes under just two headings. (This suggests that crucial instances can operate at any any level in the series of divisions that begins with the genus and ends with the form.) Given the nature of “the paths of motion,” are there any alternatives that fit the phenomena other than side-to-side and up-and-down motion?

But philosophers are very skilled at coming up with alternatives, and this question will surely meet with answers such as these: that perhaps the motion is compounded of the two, or worse, perhaps it can only be explained if we think of motion as involving more than three dimensions (some of them unperceived by us). Or perhaps the correct genus is so far beyond our current comprehension that it would never cross our minds.

I think that this is a fair objection to Bacon, and it limits the justificatory force of any merely negative crucial instance, so that I concede that Duhem is right that there are no falsifying crucial instances that establish a particular hypothesis with certainty. But falsifying crucial instances are not the only or the most important kind. As I will discuss in the next section, some crucial instances aim to establish the correct hypothesis directly and not by means of the falsification of the alternatives.

5.3.5 Reasoning Affirmatively vs. Reasoning Negatively

In this section, I argue that Bacon believes that some general causal claims can be confirmed directly, without proceeding by means of the falsification of any alternatives. I further argue that Bacon regards some crucial instances as playing this role.

Bacon first elaborates the distinction between reasoning by means of affirmatives and negatives in the *De principiis atque originibus*. There, he uses Greek myths about Cupid and Coelum as the springboard for an elaboration of “the philosophy of Parmenides and Telesio and especially that of Democritus.” Cupid turns out to be a symbol of the atom and the initial principle of motion that was imparted to it by God. In the myth as Bacon tells it, Cupid “came from an egg laid by Night.” This symbolizes the method that we are to use in investigating the atom and its first principle of motion:

Now that business of Night’s egg is a very happy allusion to the demonstrations which bring this *Cupid* to light. For things concluded by affirmatives seem to be the offspring of light, whereas those concluded by negatives and exclusions are wrung out and brought forth as if from the obscurity of night. Now this *Cupid* is truly an egg hatched by Night, for knowledge of him (all that may be had) proceeds by exclusions and negatives. But proof made by exclusion is a kind of ignorance, and as it were *Night*, with regard to what is included in it.¹⁰⁰

Because first principles have no prior natural causes—God is the only prior cause—we cannot know them, as we know everything else, by means of causes. Their primacy also makes them hard to investigate directly. We have to use an eliminative

¹⁰⁰Bacon, *Philosophical Studies*, c. 1611- c. 1619: I11^r.

method to learn anything about them. The atom is not visible, not colored, not heavy, not light, and so on.

Even when it comes to the investigation of first principles, we eventually come to affirm things of them:

But the parable further suggests that there is some end and limit to these exclusions of which I have spoken, for Night does not incubate forever. Certainly it belongs to God alone, that, when His nature is inquired of by the sense, exclusions shall not end in affirmatives. But here the case is otherwise, that is, that after due exclusions and negations something is affirmed and established, and an egg hatched, as it were, after an appropriate period of incubation and not only is it that the egg is hatched by Night but also that the person of *Cupid* is hatched from the egg, that is, not only is some notion of this matter drawn and extracted out of ignorance, but also a distinct and definite notion.¹⁰¹

What is most interesting about this passage, for my purposes, is what it implies about the method of investigating things that are *not* first principles. God is singled out as the only subject of inquiry for which the reasoning does not end in something affirmative, and the atom and its principle of motion is singled out as the only *natural* phenomenon where the affirmatives are to be sought through an exclusively eliminative process. This seems to imply that other natural phenomena can be investigated directly through affirmatives—that they can come from eggs hatched by Light, to use Bacon’s metaphor.

The sporadic mentions of reasoning with affirmatives in the *Novum organum* are compatible with my reading, but admittedly not decisive.

Now if the mind tries to proceed by affirmative instances from the start (which it always does when left to itself) the result will be phantasms, mere opinions, ill-defined and notional conclusions, and axioms altered daily, unless we want to follow the schoolmen’s fashion and fight for falsehoods. These will no doubt be better or worse according to the capacity and strength of the intellect working on them. But only to God (the creator and implanter of forms), or perhaps to the Angels and Intelligences, does immediate knowledge of forms by affirmation belong as soon as they begin thinking about them. But this is certainly beyond

¹⁰¹Bacon, *Philosophical Studies*, c. 1611- c. 1619: I12^r-I12^v.

men who are allowed only to proceed by Negatives at first, and then to finish up with Affirmatives after making every sort of exclusion.¹⁰²

This passage tells us only that the eliminative stage must precede the affirmative stage, but it does not tell us how the affirmative stage works or rule out that it works just through the affirmation of the only remaining possible cause after all others have been eliminated. The same ambiguity is present a little later on, when Bacon says that “the foundations of true *Induction* rest on the *Exclusive* process, yet the process is not finished until it ends in an affirmative.”¹⁰³

We can make some progress, though, by inquiring into what these mysterious-sounding “affirmatives” are. Here I turn to a famous passage in Book I of the *Novum organum* that deals with one of the causes of the idols of the tribe (a cause which we now call confirmation bias):

The human intellect takes the conceptions which have won its approval (by general acceptance, credit, or simple charm), and pulls everything else into line and agreement with them, and although the abundance and strength of the contrary instances it encounters is greater, the intellect at enormous cost overlooks and despises them, and dismisses them and rejects them by making distinctions to keep the conceptions just mentioned intact. So that man gave a good answer who, after being shown a picture hanging in the temple of people who, having said their prayers, escaped the perils of shipwreck, and after he was pressed to say whether he did not now acknowledge the power of the gods, asked this question in return: *But where are they depicted who, after solemn prayers, perished?* [...] But even if the charm and vanity mentioned above were absent, the human intellect would still suffer from the peculiar and permanent error of being moved and excited more by affirmatives than negatives, when it ought to pay heed in a proper and systematic way to both equally; indeed, in the true setting up of every axiom, the power of the negative instance is actually greater.¹⁰⁴

In this context, a negative instance is one that counts as evidence against a hypothesis, while an affirmative instance is one that counts in favor of a hypothesis. In the shipwreck example, the painting of men who prayed and escaped a shipwreck is an affirmative instance because it counts in favor of the hypothesis that

¹⁰²*N.O.* II. 15.

¹⁰³*N.O.* II. 19.

¹⁰⁴*N.O.* I. 46.

prayer is effective, while the many instances of men who prayed and then died are all negative instances because they count against the same hypothesis.

According to Bacon, we tend to overvalue affirmative instances and overlook negative instances. The eliminative stage of his method is meant in part to balance out that natural tendency. But affirmative instances are not to be ignored completely. There are examples of prerogative instances, such as shining instances, which play an affirmative role alongside that method of exclusion. And some crucial instances, I am now arguing, are affirmative instances as well.

This interpretation is corroborated by Bacon's metaphorical description of crucial instances as experiments of light. "And so much for *Crucial Instances* which I have dealt with at some length with the aim of getting men gradually to learn and become used to judging nature with *Crucial Instances* and light-bearing experiments, not with probabilistic reasoning."¹⁰⁵ His use of this metaphor is not entirely consistent, as sometimes he contrasts experiments of fruit, which have an immediately practical purpose, and experiments of light, whose immediate purpose is further knowledge, in such a way that even negative instances shed this metaphorical light. But the *DPAO* passage we have just examined explains the equation between crucial instances and experiments of light. Light, in this context, is to be contrasted with night, not with fruit. (Recall that Cupid comes from an egg laid by Night.) Light seems to be associated with both certainty and affirmative reasoning, while night seems to be associated with probabilistic and eliminative reasoning.

Bacon's examples confirm my reading. The crucial instances that I have classified as certain and affirmative use observations which (if the "auxiliary assumptions" are certain) we can easily imagine Bacon thinking necessitate the causal claim, regardless of whether other hypotheses have been falsified. In addition, Bacon sometimes requires more observations than would strictly be necessary to falsify the alternatives that he lists, which is evidence that he is concerned with

¹⁰⁵ *N.O.* II. 36. Here is another passage with the same metaphor: "Since I very often lack history and experiments, especially experiments of light and crucial instances which can inform the mind about the true causes of things, I give directions for new experiments suitable, as far as I can tell at present, for the subject under inquiry." Bacon, *The Instauration magna: Part III: Historia naturalis: Historia naturalis*, C4^r.

establishing the cause by means of positive evidence rather than through the mere process of elimination.

In the crucial instance concerning the rising and falling motion of the tides, the observations include information about high tides at enough key points such that one can model the motion of the water as if the globe could be observed all at once. The instance concerning the diurnal motion is very similar in this regard. If one has information about the motion of objects at all of the possible distances from the earth (from the ground all the way to the fixed stars), then one can model the motion of the universe as if the whole thing were there to be observed in a single gaze. (But as I pointed out Bacon later recognizes in the *Histria ventorum* that this model is not entirely decisive.) What warrants our extrapolating from the limited set of data to the motion of points that have not yet been recorded (because they are in places or times we have not looked) must be our background knowledge, such as background knowledge about fluid dynamics in the case of the tides.

The example concerning fire does not appeal to visual models in the same way. Instead it relies on what we now call Mill's method of difference. Only one relevant factor is changed in the experiment, i.e., whether the candle's flame is in contact with air. When the flame is shielded from the air by a surrounding flame, it no longer has its fleeting nature. (Presumably Bacon thinks the experiment would require watching the flame for a long while to see whether it lasts longer than usual. The experiment would then be liable to *ad hoc* explanations of any failures since, when the flame is finally extinguished, one would be inclined to attribute it to inadequate shielding. However, I attribute this problem to a weakness in Bacon's application of his method rather than to an intrinsic weakness of the method itself.) Therefore, the air must have been the cause of the fleetingness of the flame.

The affirmative character of this type of crucial instance suggests that Bacon would offer the following reply to contrastive arguments for underdetermination: If the observations, along with any genuine background *knowledge*, necessitate a particular causal account, then it does not matter which other hypotheses are out there waiting to be conceived.

5.4 Overview and Conclusion

I have tried to show that many of the usual objections to Bacon's quest for certainty about formal causes are based on straw men. Let us review some of the most persistent of these straw men:

Bacon is a proponent of eliminative induction In fact, his use of the method of collection and division, as well as his use of affirmative crucial instances, are important non-eliminative elements of the method. This also allows him a response to arguments for underdetermination that are rooted in the impossibility of justifying a premise that sets out a finite list of possible alternatives.

Bacon has no good way of justifying a disjunctive premise and therefore his use of the process of elimination (insofar as this is still part of his method) is useless In fact, Bacon calls for migratory instances for roughly this reason. Migratory instances can narrow down the space of possible explanations and allow us to thoroughly examine that whole space. Furthermore, although Bacon does accept the principle of limited variety, this is not his means of narrowing down the space of possible explanations. By itself, that principle would leave thousands of options. And since the options are not known *a priori*, we would perhaps need to revise them over time.

Bacon's falsification of possible explanations is vulnerable to arguments for underdetermination rooted in holism This objection seems to presuppose the failure of foundationalism. But it is not clear why we should think that the kind of foundationalism modeled in the previous chapter must be unsuccessful.

Bacon offers a complex and diverse toolbox for trying to hone in on the form of a nature, but the only tool which he explicitly puts forward as one that can achieve certainty is the crucial instance. But I hope to have emphasized that crucial instances are not self-contained. They depend on background knowledge, including the table of exclusions and the First Vintage, both those in the current

inquiry and those in any inquiries to which there are links.

The fact that the usual objections are based on straw men does not show that Bacon succeeds. But we need to turn to better scientists in order to find better examples. In the next, concluding chapter, therefore, I will offer a Baconian analysis of crucial experiments by Isaac Newton and Robert Hooke. I will argue that these episodes in the history of science confirm the sophistication of Bacon's method, but that they also reveal the need to jettison Bacon's principle of limited variety.

Chapter 6

Conclusion

I take myself to have established that Bacon seeks epistemic certainty about formal causes (in Chapter 2), and that the usual objections leveled against this aspiration can be answered through a fuller reconstruction of his methodology (in Chapters 3-5). Epistemic certainty, as discussed in Chapters 2 and 3, must mean justification beyond a reasonable doubt. Although it is logically possible to be certain about a falsehood, the locus of risk is very circumscribed. Some of the risk—perhaps it is too much to even call this “risk”—arises from the logical (but certainly not realistic) possibility that our sense organs fail to register the world. Some additional risk, which I have chosen not to address, can arise just from our tendency to make mistakes sometimes. This latter risk applies just as well to deduction and warrants no special treatment here.

At this point, there are at least two more objections to Bacon that I have not yet considered and which in my view require us to make some revisions to the account presented thus far. The first objection is that what I have established is too modest. I have cleared the field of many straw men, but I have not given a single example of Bacon’s method yielding epistemically certain results about formal causes. After all, none of us today would be inclined to think that any of Bacon’s examples of crucial instances yield much certainty about formal causes, and these seem to be the best examples that Bacon is able to offer.

So we might search the history of science for better examples. Do practitioners of Bacon’s method ever use the method to secure knowledge with certainty?

When we make this search, we come to our second objection: they don't. Time after time the beliefs which scientists thought certain eventually come to be undermined and replaced. Philosophers call this the pessimistic meta-induction.¹

But not so fast. I aim to show, by way of conclusion, that Isaac Newton and Robert Hooke, in at least some of their work, follow aspects of Bacon's methodology with some success. Furthermore, Newton's fourth rule of reasoning, which can be adopted as a revision to Bacon's method—a revision justified empirically by the application of a previous iteration of the method—offers a response to the pessimistic meta-induction. The fourth rule states that “propositions gathered from phenomena by induction should be considered either exactly or very nearly true notwithstanding any contrary hypotheses, until yet other phenomena make such propositions either more exact or liable to exceptions.”² My understanding of this rule is that it makes room for propositions inferred by induction which are certain, yet still revisable, because they are held in a qualified form. The fact that revisions may become necessary does not imply that the proposition, in its qualified form, was false. For example, when general relativity called for the revision of classical laws of free fall, it made those laws more accurate. But the classical laws are not false—or, more precisely, whether they are false depends on the manner in which they are held. If a proponent of the classical laws puts them forth as unerring descriptions of the world which never need revision, then they are false. But if the proponent of the classical laws originally puts them forth with the proviso, or *ceteris paribus* clause, that there might be unknown factors which would modify the motion of falling bodies, then the laws are not false, and the replacement of those laws with relativistic laws cannot be taken as evidence that our certainty in the classical laws is unwarranted.³

¹The pessimistic meta-induction is usually invoked in the context of the debate over scientific realism, but it has obvious implications for the debate over the certainty of principles which purport to describe reality.

²Newton, *The Principia: Mathematical Principles of Natural Philosophy*: p. 796.

³*Ceteris paribus* laws are subject to the objection that they must either be false or trivially true. I will come back to this objection. I also have to concede that this argument about *ceteris paribus* laws offers a response to the pessimistic meta-induction but does not in itself establish affirmatively that particular principles that are appropriately qualified are certain. My view is that this is a question to be settled by consulting the history of science.

Examining the Baconianism of Newton and Hooke offers another benefit too. If they understand Bacon as I do on some key issues, such as the affirmative, non-eliminative nature of crucial experiments, then this is at least a modest confirmation of the reading of Bacon I have offered.

This concluding chapter will be structured as follows: 6.1 explains why Bacon's method requires further revision; 6.2 turns to Newton and Hooke to illustrate more promising examples of the Baconian method in practice; and 6.3 offers a summary of the dissertation and a reflection upon what my overall account means for the nature of the distinction between induction and deduction.

6.1 A Proposed Revision to Bacon's Method

Bacon seems to imagine that his ultimate results will never need to be revised. I think he is mistaken and that the principle of limited variety lies at the root of his mistake. In this section, I will explain why that principle should be challenged, and I will offer Newton's fourth rule of reasoning as a promising way to begin revising Bacon's method in response. (Perhaps more important than this particular revision, though, is the point that Bacon's method allows for revision in general; this feature of the method is itself one of the resources on the basis of which Bacon can defend his ambition for certainty.)

Recall that the principle of limited variety states that there are a finite number of simple natures in the universe. In Chapter 5, I argued that this principle does not play much of a role in narrowing down the space of possible causes and that it therefore does not do much to fortify the eliminative part of Bacon's method. Nevertheless, the principle does lie behind Bacon's ambition for certainty in another way. For if we add to the principle of limited variety the assumption that we have perceptual or inferential access to many and diverse instances of each of the simple natures in the universe, then the path to certainty is clear. If there is only so much out there to be known, then it is just a matter of time before our natural histories cover the full range of actual and possible instances. It is for this reason that Bacon expects the natural histories to stabilize over time, such that

they can eventually be written in pure form, as fewer and fewer changes become necessary.

Otherwise, the revision mechanisms discussed in Chapter 3 could, in principle, continue indefinitely. If there may always be new kinds of instances to add to our natural histories, either because the principle of limited variety is false and there are an endless number of simple natures or because (even if the principle of limited variety is true) the universe is so vast or there are regions inaccessible to us, so that we never be sure that we have succeeded in gathering data about the full range of instances, then we have a problem. Our statement of a formal cause must specify the properties that are necessary and sufficient for the nature in question. It must pick out all of the instances with that nature and only the instances with that nature. As long as our natural histories may always be revised further, what suffices to pick out the instances with a nature today may not suffice tomorrow.⁴

Suppose, for example, that we are inquiring into the nature of sound. We have been very cautious Baconians and have waited until we could fill our natural history with information from unexplored realms: under the sea, in space, behind newly invented materials, etc. We reach a point where there are no obvious gaps in our natural history and it goes a long period of time without having to be revised. So we affirm that sound is the vibration of a medium. Now what do we do when someone comes along and provides some evidence that light too is the vibration of a medium? Should we preserve our definition by adding light as an instance of sound, or should we add further necessary conditions to our definition of sound in order to distinguish it from light?

⁴Although they are posed as a critique of Mill's Methods, some comments by Hart and Honoré are fitting here: "Even the scientist can only discover uniformities which he has evidence for believing will hold good over a far wider range of conditions than any that can be discovered by common sense: he does not assert or have grounds for asserting that they will hold good under 'all possible conditions' (unconditionally) or 'always' (invariably). This is in fact an absurdity both in practice and principle. To meet such a standard there would have to be evidence that 'everything' (*all* other things, events, or states) apart from the set of conditions specified in the generalization was irrelevant, so that the specified conditions would be unconditionally and invariably sufficient. [...] Apart from these practical difficulties, the supposition that there are in the 'universe' a finite number of things or events or states, which in principle could be examined and found relevant or irrelevant, is chimerical; the 'universe' is not a box with a finite number of objects in it, each describable in a finite number of ways." Hart and Honoré, *Causation in the Law*: p. 45.

John McCaskey has argued that we can reach a stage where, because we have certainty about formal causes, we can be warranted in preserving our definition (see Chapter 5). So *if* we were certain that sound just is the vibration of a medium, and *if* we were certain that light too is the vibration of a medium, then we should indeed classify light as an instance of sound.

McCaskey offers some examples where this move seems plausible. First, we define cholera nominally as a cluster of symptoms, but then we arrive at a causal definition which states the form. Cholera is discovered to *be* an infection of the small intestine caused by a particular bacterium (*vibrio cholerae*), and we define it accordingly. So if a different bacterium causes the same symptoms, we should file the disease under a different concept and preserve our definition (even though under the old nominal definition the new instance would have been subsumed, just as spicy food is initially classified as an instance of heat but later on rejected based on the new causal definition). What makes this move plausible is that we think we already know a lot about bacteria and genetics. This has the same effect on us as does the general acceptance of the principle of limited variety—we are confident that no recalcitrant instance will present itself. But even in this case, it is rash to insist that our definition be preserved come what may. Suppose we discover another planet with a bacterium that is functionally similar to cholera but embodied in non-organic matter. When it infects our small intestines, do we now have cholera or not? *Perhaps* McCaskey would be right to say that we shouldn't call our disease cholera. But is this a question that should be settled merely by deduction from our definition of cholera? I don't think so.

What hinges on this? After all, one might think that even if one excludes the new instance from one's concept of *cholera*, we may invent a new concept to cover the broader phenomenon—call it *schmolera*—that includes both cholera and the alien phenomenon. Alternatively, if we include the new instance in our concept of *cholera*, we will want a new concept to single out terrestrial cholera only—call it *T-Cholera*. So whichever choice we make about the alien phenomenon, we end up with a narrower concept that may keep the existing definition (termed either *cholera* or *T-cholera*) and a broader concept that includes both types of

phenomena. (termed either *cholera* or *schmolera*). The terms attached to the concepts differ, to be sure, but what's in a name?

This move might be right. What I think is more worrisome is that our discovery of the broader phenomenon, whatever we call it, might provide one with reason to revise one's understanding of the nature of the narrower one. Take the commotion over whether Pluto is a planet. The need to reevaluate its planetary status was brought on by the discovery of additional Kuiper Belt objects which had just as much right to be called planets as did Pluto. So scientists had a choice: include many more objects as instances of planets, or include one fewer object. Again, not much hinges on the choice of terms. What is more important is that these Kuiper Belt objects made salient some previously neglected features that are common to all of the planets except Pluto. The understanding that some objects have "cleared the neighbourhood" around their orbits (meaning roughly that there are no other gravitationally dominant objects sharing the space around their orbit), while others have not, owes itself to the need to contrast the planets with the Kuiper Belt objects. This is a revision to our idea of 'planet,' not just a revision to our terminology.

So in my view, there is no way to rule out the possibility of additional instances being discovered and providing us with reason to revise our claims about formal causes. But now we need to ask whether this is a barrier to epistemic certainty. This is where Newton's fourth rule of reasoning comes in.

Newton was troubled by the tendency of his contemporaries to object to his conclusions merely by conceiving of alternative hypotheses (see 6.2.1 below). ("*Maybe* there is something functionally identical to cholera that is not cholera" would be an example of this sort of thing.) Even if those other hypotheses can save the phenomena, as the Cartesians claimed the hypothesis of vortices could do with regard to celestial motions, Newton believed that he could be certain of any conclusions he had induced from the phenomena and that the mere possibility of alternatives is not a good reason for doubt.

Thus he conceived his fourth rule of reasoning: "propositions gathered from phenomena by induction should be considered either exactly or very nearly true

notwithstanding any contrary hypotheses, until yet other phenomena make such propositions either more exact or liable to exceptions.”⁵ To this is added what purports to be a justification of the rule: “This rule should be followed so that arguments based on induction be not be nullified by hypotheses.”

The justification of the rule is pragmatic and not my main concern here. Newton does not claim *here* that we can be certain that contrary hypotheses are false, but only that were we to entertain their truth, inductive argumentation would be threatened and that we therefore we should not entertain their truth.

What I want to emphasize about the rule is the kind of revision that Newton allows for, which goes beyond the kind allowed by Bacon. For Bacon, the process of revision is confined to the first five parts of the *Instauratio*. He gestures towards the possibility of inexact generalizations that might be true, despite the existence of exceptions, when he discusses Instances of Companionship and Hostility (see Chapter 4). But those are supposed to be entries in a natural history and are not to be taken as statements about formal causes destined for Part Six of the *Instauratio*. Newton, in contrast, says that there are two possible kinds of revision that we must always allow for. Propositions can be made more accurate, or exceptions can be specified. As long as we look upon those propositions as accurate or very nearly true, rather than as exactly true, these subsequent revisions do not imply that we were in error before making those revisions.

Here is an alternative formulation (or perhaps a further revision) of Newton’s point. As long as we add an appropriate *ceteris paribus* clause to a proposition that we have proved, the conclusion will not be threatened by future discoveries. This is why *ceteris paribus* clauses are sometimes considered useful as hedging devices. Now, there are two kinds of *ceteris paribus* laws, comparative and exclusive.⁶ Suppose a law is understood as a certain kind of conditional proposition.⁷

⁵Newton, *The Principia: Mathematical Principles of Natural Philosophy*: p. 796.

⁶See the SEP: Reutlinger, Schurz, and Hüttemann, “Ceteris paribus laws”.

⁷It is important, I think, to distinguish between scientific laws and laws of nature. Some of the objections to *ceteris paribus* laws would apply only if they are taken to be laws of nature, whereas they should instead be taken to be scientific laws. I take the distinction to be this: laws of nature (if there are any) are fundamental, governing, and exist independently of us. A scientific law is a verbal expression of a non-accidental regularity, where the regularity does not need to be fundamental.

Comparative *ceteris paribus* laws hold factors *constant* if they are not mentioned in the antecedent or consequent of the conditional. For example:

Law: If the temperature of a gas increases, the volume will increase proportionally.

A factor absent from the antecedent and consequent: pressure.

So a comparative *ceteris paribus* version of this law might say that *if* the pressure is held constant, then if the temperature of a gas increases, the volume will increase proportionally.

Exclusive *ceteris paribus* laws, on the other hand, *exclude* disturbing factors entirely (rather than holding them constant), so that the law is restricted to idealized scenarios and may have to be modified in order to predict the exact behavior of things in real-world conditions. Those disturbing factors might be listed, but more often than not a full list cannot be provided. For example:

Law: If an object is a planet, it will travel in an elliptical orbit with the Sun at one of the foci of the ellipse.

A partial list of disturbing factors: Additional forces on the planets, forces on the Sun, the bending of space-time.

So the qualified law might say that *if* disturbing factors (such as outside forces and the bending of space-time) are excluded, then if an object is a planet, it will travel in an elliptical orbit with the Sun at one of the foci of the ellipse. Note that we might not yet be aware of all disturbing factors, but even so, we can qualify the law to exclude unknown disturbing factors as well as the known ones.

Imagine, then, that we could drop Bacon into the modern world and persuade him to abandon the principle of limited variety. My suggestion is that he might revise his method by requiring the judicious use of *ceteris paribus* clauses or some other such hedging device, and hold onto his ambition for certainty.⁸

⁸A common objection to exclusive *ceteris paribus* laws is that they face the dilemma of being false if understood in one way or trivially true if understood in another. If they are taken as descriptions of idealized circumstances, then one might object that the laws fail to describe the real world. On the other hand, if one understands them as describing the way the real world

6.2 Case Studies

In 6.2.1, I discuss the case of Newton’s reasoning about the heterogeneity of white light, as well as Newton’s responses to Robert Hooke’s objections. (Hooke’s objections are interesting because they amount to the charge that Newton’s experiments underdetermine Newton’s theory.) Then in 6.2.2, I discuss two crucial experiments by Robert Hooke.

6.2.1 Newton’s Optics

Newton’s 1672 letter to the Royal Society, in which he announced his discoveries about light and color as well as a plan for a reflecting telescope, is increasingly being read as genuinely Baconian in various ways.⁹ For my purposes here, it is not important that I establish Bacon’s direct or indirect influence on Newton.¹⁰

would be if disturbing factors were excluded and then just defines a disturbing factor as anything that would prevent the law from being true, then the law is true just in virtue of the meaning of the term “disturbing factor.” The qualified version of the law amounts to the claim that the unqualified version of the law is true except when it isn’t. In that case, it could be a law that you always wake up before 7 am because, whenever you wake up later, you can cite the factors that caused you to wake up later. It is clear that this law would be false without the qualification, and that it is trivially true when the qualification is added. Philosophers have attempted a number of responses to this kind of objection. The debate is still a live one, and it would take me too far afield to rehearse it here. I am more interested in modeling the kind of scientific work that a revised form of Bacon’s method makes possible than in entering this contemporary debate.

⁹Dana Jalobeanu ties the letter into her own reading of the method of Baconian natural history in Jalobeanu, “Constructing natural historical facts: Baconian natural history in Newton’s first paper on light and colors”: forthcoming. She emphasizes the role of literate experience in producing a series of experiments as well as similarities between Newton’s conception of a crucial experiment and Bacon’s ((mainly, that crucial experiments are not to be thought of in isolation from the rest of the natural historical series of which they are part, a point which I also wish to stress as *part* of my interpretation). Raftopoulos argues that Newton’s reasoning is eliminative, although he does not explicitly trace this adoption of eliminative reasoning to Bacon. (Bacon is mentioned only once by Raftopoulos for his shared view with Newton that discovery and justification coincide.) Raftopoulos, “Newton’s Experimental Proofs as Eliminative Reasoning”.

¹⁰Yet I do believe there is a good deal of influence. Newton’s copy of Bacon’s *Historia densi et rari* is thoroughly marked up, and Newton’s fellows in the Royal Society provided Newton with frequent secondhand encounters with Bacon’s ideas, both in their works (such as Hooke’s *Micrographia*, the preface to which reads like a summary of a good portion of the *Novum organum*, and presumably in the course of private conversations. Steffen Ducheyne has recently argued for Bacon’s influence on Newton’s *Principia*, although I am not persuaded he has found much of significance other than a kindred, and unsurprising, rejection of enumerative induction in favor of something more methodical and gradual. Ducheyne, “Bacon’s Idea and Newton’s Practice of Induction”.

Whatever his sources, Newton does in fact follow some of the methodological principles I have discussed in this dissertation, and in contrast to Bacon, it is plausible that Newton succeeds in using these principles to arrive at epistemically certain conclusions about causes. Although Newton asserts a number of additional conclusions in his letter, what he claims to demonstrate with certainty is that “*Light consists of Rays differently refrangible,*” and is a “*Heterogeneous mixture of differently refrangible Rays*” and that it is this fact about the nature of light which accounts for the oblong spectrum obtained when light is passed through a prism.¹¹ The dispersion of the light is caused not by any modification of the light as it passes through the prism, but is rather caused by the separation of the differently refrangible rays that are already contained in the sunlight.

Others before me have already told this story in more detail than would be appropriate by way of conclusion to my interpretation of Bacon. Here I aim only to use Newton’s theory of light—and especially his crucial experiment—as an example to make an empirical case that claims about causes can be established with certainty by means of a Baconian method.

Newton’s letter begins with a simple experiment that seems to conflict with Snell’s Law, or the sine law of refraction. This law, which states that for an interface between two given media the sine of the angle of incidence of a ray of light is proportional to the sine of its angle of refraction, was viewed by Newton and his contemporaries as a well-established truth. Newton himself was willing to subject the law to revision (as he was with respect to all laws), but not to throw it out entirely.

having darkened my chamber, and made a small hole in my window-shuts, to let in a convenient quantity of the Suns light, I placed my Prisme at his entrance, that it might be thereby refracted to the opposite wall. It was at first a very pleasing divertisement, to view the vivid and intense colours produced thereby; but after a while applying my self to consider them more circumspectly, I became surprised to see them in an *oblong* form; which, according to the received laws of Refraction, I expected should have been *circular*.¹²

¹¹Newton, *The Correspondence of Isaac Newton*: “Newton to Oldenburg,” p. 95.

¹²Ibid.: p. 92.

Newton does not specify the position of his prism, but it is clear that it must be in the so-called position of minimum deviation (because otherwise Snell's Law would predict a more oblong spectrum and there would be no mystery). This means that one must turn the prism on its axis until the overall path of the light is as close to straight as possible. Newton later measures the spectrum that is produced to confirm that Snell's Law does not accurately describe the path of sunlight that is passed through a prism at the angle of minimum deviation. The unstated implication is that either Snell's Law is false or some cause is present in this case that is interfering with its application. Newton, adhering provisionally to Snell's Law, searches for a cause of the oblong spectrum that is compatible with its being at least approximately true.

The next stage of the argument is eliminative. (At one point he refers to his procedure as the "gradual removal of these suspicions."¹³) In a series of experiments, Newton rules out a number of possible causes.

1. The fact that rays that are incident at different spots on the prism have to traverse slightly thicker or thinner parts of the prism. Newton shows that the thickness of the glass is irrelevant by passing the sunlight first through thicker and thinner parts of the glass and observing no effect.
2. "The termination with shadow or darkness."¹⁴ Here Newton targets a particular variety of modificationism (Zemplén calls it boundary-modification¹⁵). Modificationist theories assert that white light is pure and that colors are created when something modifies that light. These theories can be classified according to *what* is taken to be responsible for this modification. Here Newton targets those who would try to explain the oblong spectrum by reference to some modification by the dark areas adjacent to the rays of light on the side of the hole opposite the sun. By altering the size of the hole and placing the prism in front of the hole, so as to complete the refraction prior to any possible action by the areas in shadow, Newton takes himself to rule out this

¹³Newton, *The Correspondence of Isaac Newton*: p. 94.

¹⁴Ibid.: p. 92.

¹⁵Zemplén, "Newton's Rejection of the Modificationist Tradition": p. 7.

variety of modificationism as the cause of the oblong spectrum.

3. Newton next tries to rule out varieties of modificationism which assign the cause of modification to irregularities within the prism. He adds a second prism, positioned in such a way as to reverse the dispersion (see Figure 6.1). Newton reasons that if some irregularity within the prism modified the white light, then the modification would be augmented, not reversed, by the second prism.

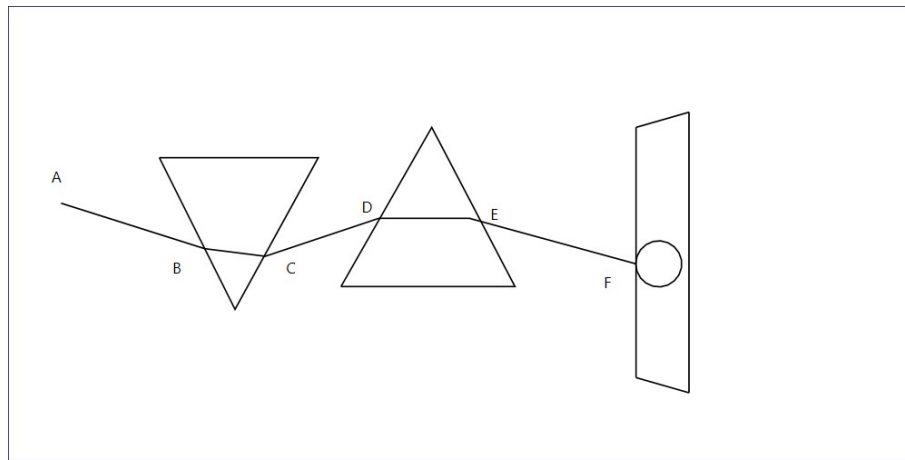


Figure 6.1: Inverted Prisms

When the second prism is inverted relative to the first, it cancels out the effects of the first. The resulting image on the screen (at F) is both circular and white.

4. Not all of the rays of light falling upon the prism have the same angle of incidence. Could these varying angles of incidence cause the oblong spectrum? Newton rules this possibility out in two ways. The first way presupposes that Snell's Law can be applied. Using the law, he calculates the magnitude of the effect and measures his spectrum to show that the differing angles of incidence are not sufficient to explain the oblong spectrum. Then, without using Snell's Law, he rotates the prism on its axis in order to show that varying the angle of incidence does not have an effect sufficient in magnitude to account for the oblong spectrum.
5. Next Newton considers and rejects a semi-Cartesian hypothesis according to

which the prism modifies the light by imparting spin to the particles and thereby causing them to move in curved lines (just as spin can cause a tennis ball to curve). Newton rules this hypothesis out by varying the distance from the prism to the screen on which the spectrum is projected. The spectrum increases in size with the distance in a linear proportion. The rays of light therefore do not curve.

Such is the eliminative stage of the method. What does it show? Newton says that removing these hypotheses helps *lead* him to the crucial experiment,¹⁶ so they might seem to be of heuristic value only. I will come back to this question, though, because it turns out that the crucial experiment is not self-contained, but instead requires that the space of possible causes be already narrowed down. So these prior experiments are needed in order to justify Newton's interpretation of the crucial experiment.

The setup of Newton's crucial experiment is as follows (see Figure 6.2).

I took two boards, and placed one of them close behind the Prisme at the window, so that the light might pass through a small hole, made in it for the purpose, and fall on the other board, which I placed at about 12 feet distance, having first made a small hole in it also, for some of that Incident light to pass through. Then I placed another Prisme behind this second board, so that the light, trajected through both the boards, might pass through that also, and be again refracted before it arrived at the wall. This done, I took the first Prisme in my hand, and turned it to and fro slowly about its *Axis*, so much as to make the several parts of the Image, cast on the second board, successively pass through the hole in it, that I might observe to what places on the wall the second Prisme would refract them. And I saw by the variation of those places, that the light, tending to that end of the Image, towards which the refraction of the first Prisme was made, did in the second Prisme suffer a Refraction considerably greater then the light tending to the other end. And so the true cause of the length of that Image was detected to be no other, then that *Light* consists of *Rays differently refrangible*, which, without any respect to a difference in their incidence, were, according to their degrees of refrangibility, transmitted towards divers parts of the wall.¹⁷

¹⁶Newton, *The Correspondence of Isaac Newton*: p. 94.

¹⁷Ibid.: pp. 94-5.

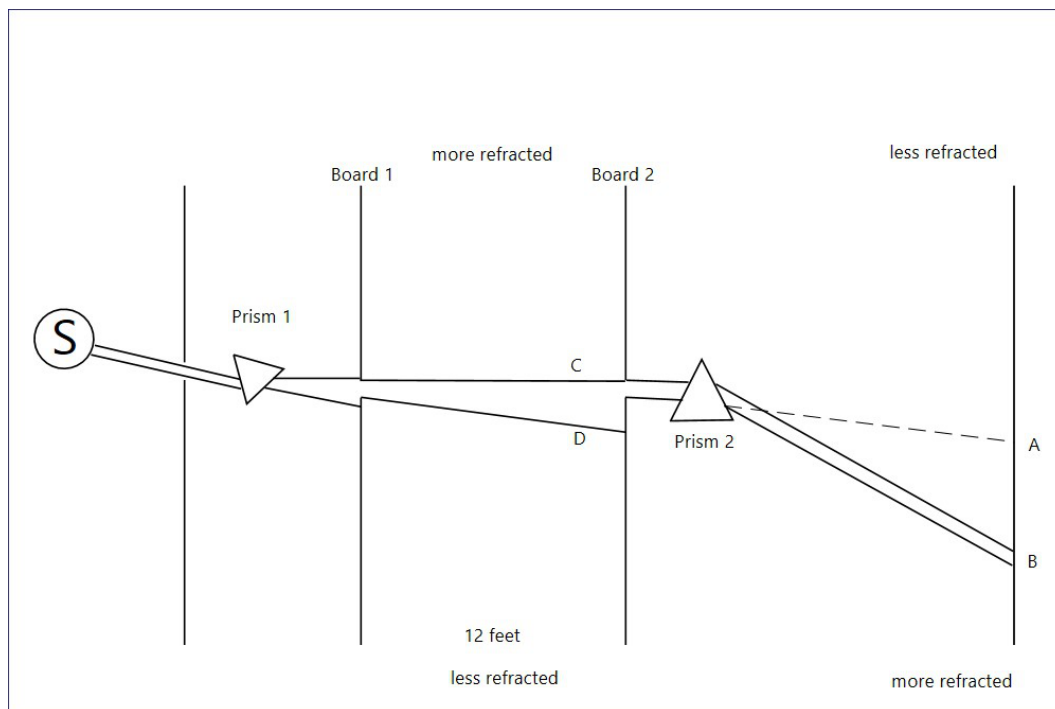


Figure 6.2: Newton's Crucial Experiment

Everything is fixed in place except for Prism 1, which can be turned on its axis. When the light that is more highly refracted (near C) by Prism 1 is allowed to pass through Prism 2, it is once again more highly refracted and falls upon position B on the screen. If Prism 1 is turned so that the less refracted light (near D) falls upon Prism 2, then the light will be less refracted by Prism 2 and fall instead on position A on the screen. Since the angle of incidence on Prism 2 is held constant, and all that changes is whether the light passing through Board 2 was more refracted or less refracted by Prism 1, the different rays of light must themselves have dispositions to be refracted to different degrees. The diagram closely follows Sepper, *Newton's Optical Writings: A Guided Study*: p. 36.

It is easiest to describe the experiment by tracing the trajectory of the light. The light comes in through a hole in the shutter and passes through the first prism (which can be rotated on its axis and need no longer be held at the position of minimum deviation), Next there is a board with a small aperture in it. This board is held in place so that, as the first prism is rotated, rays of different refrangibility will pass through the aperture. (The rays that pass through will also vary in color, but Newton deliberately refrains from describing the experiment in terms of color at this point because he does not want to commit to any claims about the nature of colors.) Twelve feet further on, a second board with an aperture is placed to select an even more delimited range of the spectrum. Then comes a second prism, and lastly there is a screen for the light to fall upon.

The experiment calls for only one factor to be varied, the position of the first prism, and for everything else to be held in place, with the result that the angle of incidence on the second prism is constant as well, regardless of the varying degree of refraction that the light suffered upon going through the first prism. Changing this independent variable leads to a change in a dependent variable, the angle of refraction through the second prism (which can be observed easily by looking at the shifting position of the image on the screen at the end). So the ray that one selects (and which should be distinguished from other rays by its degree of refraction through the first prism, rather than by its color) must be the cause of the degree of refraction obtained after the second prism. In other words, the rays themselves must have dispositions to be refracted to different degrees. This experiment, like Bacon's crucial experiment involving one flame inside another, relies on what we now call Mill's method of difference.

In a passage deleted by Oldenberg from the original draft of the letter (and the substance of which Newton repeats in subsequent correspondence), Newton emphasizes that his reasoning proceeds neither by elimination nor by hypothetico-deduction. (Newton is not commenting on the crucial experiment specifically here, but the crucial experiment must be one instance of what he has in mind.)

A naturalist would scarce expect to see the science of those become mathematicall, yet I dare affirm that there is as much certainty in it as in any other part of Opticks. for what I shall tell concerning them

is not an Hypothesis but most rigid consequence, not conjectured by barely inferring 'tis thus because not otherwise or because it satisfies all phænomena (the Philosophers universall Topick,) but evinced by the mediation of experiments concluding directly without any suspicion of doubt.¹⁸

I take this as confirmation that Newton agrees with Bacon (as I read him) that our inquiry into causes can be brought to a level of certainty when we can finish up with affirmatives. The crucial experiment is not supposed to establish the differential refrangibility of light by falsifying alternatives. It is supposed to show directly that only one cause of the differential refraction is possible. But in contrast to Bacon's experiment with the flames, this one is compelling.

It has to be noted that Newton distinguishes between the kind of certainty available in mathematics and the kind available in physics, and there is some debate over the nature of this distinction:

In the last place I should take notice of a casual expression wch intimates a greater certainty in these things than I ever promised, viz: The certainty of *Mathematicall Demonstrations*. I said indeed that the *Science of Colours was Mathematicall & as certain as any other part of Optiques*; but who knows not that Optiques many other Mathematicall Sciences depend as well on Physicall Principles as on Mathematicall Demonstrations: And the absolute certainty of a Science cannot exceed the certainty of its Principles.¹⁹

This is not the place to work out the full details of Newton's conception of certainty. My view, at least, is that Newton believes that his fourth rule of reasoning must be applied to empirical sciences but not to mathematics. And as I read the fourth rule, it provides pragmatic grounds for holding ourselves absolutely certain of empirical laws in their qualified form.

It is well-known, however, that many of Newton's contemporaries, including Christian Huygens and Robert Hooke, were not persuaded that the crucial experiment was successful. Here Robert Hooke takes a jab at Newton:

But, how certain soever I think myself of my hypothesis (which I did not take up without first trying some hundreds of experiments) yet I

¹⁸Newton, *The Correspondence of Isaac Newton*: pp. 96-7.

¹⁹Ibid.: p. 187.

should be very glad to meet with one *experimentum crucis* from Mr. NEWTON, that should divorce me from it. But it is not that, which he so calls, will do the turn; for the same phenomenon will be solved by my hypothesis, as well as by his, without any manner of difficulty or straining: nay, I will undertake to shew another hypothesis, differing from both his and mine, that shall do the same thing.²⁰

Hooke believed that light consisted of pulses which were modified in the course of refraction. He allows that Newton's explanation of the crucial experiment is successful, in the sense of being empirically adequate, but he insisted that other explanations can be just as successful while also offering a greater degree of simplicity.

Nor would I be understood to have said all this against his theory, as it is an hypothesis; for I do most readily agree with them in every part thereof, and esteem it very subtil and ingenious, and capable of solving all the phaenomena of colours: but I cannot think it to be the only hypothesis, nor so certain as mathematical demonstrations.²¹

In response to these objections, Newton held his ground:

On [the *Experimentum Crucis*] I chose to lay the whole stresse of my discourse, which therefore was the principall thing to have been objected against. But I cannot be convinced of its insufficiency by a bare denyall without assigning a reason for it. I am apt to believe it hath been misunderstood. For otherwise it would have prevented the discourses about rarefying & splitting of rays, because ye designe of it is to show that rays of divers colours considered apart do at equall incidences suffer unequall refractions, without being split, rarefied, or any ways dilated.²²

This passage just clarifies what I have already said: that the crux of the crucial experiment is the method of difference. Hooke has this passage in mind when he responds as follows (and we will have to take this as Hooke's final riposte since this letter appears never to have reached Newton, and we have no evidence of a further response from Newton):

²⁰Newton, *The Correspondence of Isaac Newton*: "Hooke to Oldenburg," pp. 110-11.

²¹Ibid.: p. 113.

²²Ibid.: "Newton to Oldenburg," pp. 186-7.

To his reasoning about ye first of these I have only this to say that he doth not bring any argument to prove that all colours were actually in every ray of light before it has suffered a refraction, nor does his *experimentum Crucis* as he calls it prove that those proprietyes of colourd rayes, which we find they have after their first Refraction, were Not generated by the said Refraction. for I may as well conclude that all the sounds that were produced by the motion of the [? strings] of a Lute were in the motion of the musitians fingers before he struck them, as that all colours wch are sensible after refraction were actually in the ray of light before Refraction. All that he doth prove by his *Experimentum crucis* is that the colourd Radiations doe incline to ye Ray of light with Divers angles, and that they doe perservere to be afterwards by succeeding mediums diversly refracted one from an other in the same proportion as at first, all wch may be, and yet noe colourd ray in the light before refraction; noe more then there is sound in the air of the bellows before it passt through the pipes of ye organ—for A ray of light may receive such an impression from the Refracting medium as may distinctly characterize it in after Refractions, in the same manner as the air of the bellows does receive a distinct tone from each pipe, each of which has afterwards a power of moving an harmonious body, and not of moving bodys of Differing tones.²³

Hooke here says that the experiment proves *that* things happen as Newton says, but it does not prove that they happen for the reason that Newton says. The problem is that what is held constant, when the method of difference is applied, is the angle of incidence of the *already refracted* ray. But it is not obvious that the properties of the already refracted ray should tell us anything about the properties of the light before the first refraction. It is possible, according to Hooke, that the first prism imparted particular degrees of refrangibility to the resulting light rays and that that those degrees of refrangibility were not characteristic of the light before it went through the first prism.

Hooke's error here lies in thinking that the crucial experiment is supposed to be self-contained. The possibility he proposes has already been ruled out by the eliminative stage of the argument in the third experiment above.²⁴ But Hooke has a response to that experiment too, which is the idea that "unlike motions may

²³Newton, *The Correspondence of Isaac Newton*: "Hooke to Lord Brouncker," p. 203.

²⁴This at least is my reconstruction of the dialectic between Newton and Hooke. I think each often talks past the other, and in this context I think it is appropriate to abstract away from the threads of argument that don't get to the substantive disagreements between the two.

coalesce into an uniform motion & part againe and recover their former unlikenesse.”²⁵ What might be happening in the third experiment is that the homogenous light enters the first prism, which disperses it, and then enters the second prism, which recombines it. And there is no reason not to think that upon recombining the light becomes homogenous once again.

Now Newton’s answer would have to come down to the definitions of *homogeneity* and *heterogeneity*. Hooke seems to think that Newton believes that white light is heterogeneous in that it consists of a mixture of different kinds of corpuscles, while each individual color is homogenous in that it consists in corpuscles of the same kind. But Newton never claims certainty about the corpuscular nature of light and means something very limited by the concepts of *homogeneity* and *heterogeneity*:

The Light whose Rays are all alike Refrangible, I call Simple, Homogeneous, and Similar; and that whose Rays are some more Refrangible than others; I call Compound, Heterogeneous, and Dissimilar. The former Light I call Homogeneous, not because I would affirm it so in all respects, but because the Rays which agree in Refrangibility, agree at least in all those their other Properties which I consider in the following Discourse.²⁶

Refrangibility, in turn, is defined as the “Disposition [of light rays] to be refracted or turned out of their Way by passing out of one transparent Body or Medium into another. And a greater or less Refrangibility of Rays is their Disposition to be turned more or less out of their Way in like Incidences on the same Medium.”²⁷ These definitions allow us to reframe the crucial experiment (and to provide what one might have thought missing—a disjunction—if Newton is following the Baconian formula.) Light (including sunlight) is either homogenous or heterogenous. Note that this alternative does not exhaust all of the logical possibilities. Light might, for example, not have dispositions for refrangibility at all, whether equal or unequal. Newton’s crucial experiment shows that that once a ray emerges with a particular degree of refrangibility from the first prism, it maintains that degree

²⁵Newton, *The Correspondence of Isaac Newton*: “Hooke to Lord Brouncker,” p. 201.

²⁶Newton, *Opticks*: Book I, Def. VII.

²⁷Ibid.: Def. II.

of refrangibility for all subsequent refractions. But as we have seen, we are so far looking only at the already refracted ray. Why think that before the first refraction the light is heterogeneous?

One might think that the light is obviously heterogeneous, on the current definition, because it is not all bent to the same degree. But to prove heterogeneity we must show in addition that it bends unequally *because* of dispositions of the rays of light rather than because of a disposition *of the prism* to disperse rays of light. Now that we have framed the problem this way, it is clearer how the third experiment is important. If the prism had a disposition to disperse rays of light that themselves had no disposition to be refracted to different degrees, then the addition of a second prism ought to result in still more dispersion.

Newton's experiment is a good model of what Bacon hopes for. In Newton's mind, it provides certainty—and that certainty is established by means of a natural history that includes a series of experiments, a list of exclusions based on those experiments, and then an affirmative crucial experiment. But Newton's revision to Bacon is also important. Sunlight consists in differently refrangible rays, but if additional factors are discovered which are relevant to the heterogeneity of light, then the law could be made more exact or exceptions could be specified (without, in Newton's mind, threatening the certainty of the law).

6.2.2 Robert Hooke's Crucial Experiments

For all of his criticisms of Newton's crucial experiment, Hooke too fashioned himself a Baconian and placed great weight on crucial experiments, elaborating at length on one of them in his *Micrographia* and on another in a short treatise titled *An Attempt to Prove the Motion of the Earth by Observations*. This fact shows that his objection to Newton was not that Newton endeavored to find a crucial experiment, but that the crucial experiment he offered was not in his (I think mistaken) opinion good enough to establish a single hypothesis affirmatively and with certainty. I will discuss Hooke's two crucial experiments chronologically, beginning with the one in the *Micrographia*. However, the first example I will

discuss not because I think it particularly successful, but primarily because it confirms some aspects of my reading of Bacon.

The crucial experiment appears well into Observation IX, “Of the Colours observable in Muscovy Glass, and other thin Bodies,” which reports various phenomena involving colors produced by thin films and plates. (Muscovity glass is mica, which is interesting because it displays what we now know to be an interference pattern under the microscope.) The section begins with a report of the phenomena gestured at in the section’s title. Then he transitions into an inquiry into the cause of color. “These Phænomena, being so various, and so truly admirable, it will certainly be very well worth our inquiry, to examine the causes and reasons of them, and to consider, whether from these causes demonstratively evidenced, may not be deduced the true causes of the production of all kind of Colours.”²⁸ Hooke explains that the reason he wants to take up this causal question now rather than stick to natural history is because of how instructive the experiments with mica and other thin films are. In other words, they afford prerogative instances.

After discussing some variations of the experiments with films and plates (perhaps following here Bacon’s method of literate experience), Hooke turns to his crucial experiment:

But above all it is most observable, that here are all kind of Colours generated in a *pellucid* body, where there is properly no such refraction as *Des Cartes* supposes his *Globules* to acquire a *vertuity* by: For in the plain and even Plates it is manifest, that the second refraction (according to *Des Cartes* his Principles in the *fifth section of the eighth Chapter of his Meteors*) does regulate and restore the supposed *turbinated Globules* unto their former uniform motion. This Experiment therefore will prove such a one as our *thrice excellent Verulam* calls *Experimentum Crucis*, serving as a Guide or Land-mark, by which to direct our course in the search after the true cause of Colours. Affording us this particular negative Information, that for the production of Colours there is not necessary either a great refraction, as in the Prisme; nor Secondly, a determination of Light and shadow, such as is both in the Prisme and Glass-ball. Now that we may see likewise what affirmative and

²⁸Hooke, *Micrographia: Or Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses*: p. 49.

positive Instruction it yields, it will be necessary, to examine it a little more particularly and strictly; which that we may the better do, it will be requisite to premise somewhat in general concerning the nature of Light and Refraction.²⁹

The distinction between “negative Information” and “affirmative and positive Instruction” is interesting and suggests that Hooke may share my reading of Bacon, which allows for both falsifying and affirming crucial instances. This one, according to Hooke, seems to fit both categories. As for whether it is supposed to be probable or certain, it is difficult to say just yet. His talk of demonstrative evidence and true causes suggests but does not necessitate an aspiration to certainty. We need to look at the experiment itself to see if we can confirm that this is his aspiration.

Let us start with the negative Information. Hooke believes that the experiments with mica and other thin films refute Descartes’s theory, according to which color is caused by the spin imparted to globules of aether as they pass through refracting surfaces. Importantly, this spin can be reversed, and the light restored to its original white color, by reversing the refraction. The problem for Descartes’s theory, according to Hooke, is that the mica ought to reverse the spin and restore the whiteness to the light. The light enters the glass and is refracted by the top layer, is reflected off the bottom layer, and should be refracted in the opposite direction upon reentering a parallel top layer. Yet the mica produces rings of color. Descartes appears to be unable to explain this phenomenon.

Hooke says that a digression into the nature of light and refraction is now necessary. In a passage that echoes Bacon’s investigation into the nature of heat, Hooke first establishes (relying in part on the apparent shining instance of fluorescent diamonds³⁰) that the genus of light is motion and then specifies further (following Bacon’s procedure of introducing successive differentiae where each is a modification of the preceding) that the motion is quick and vibrative and that the

²⁹Hooke, *Micrographia: Or Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses*: p. 54.

³⁰“But there is one Instance more, which was first shewn to the *Royal Society* by Mr. *Clayton* a worthy Member thereof, which does make this Assertion more evident then all the rest: And that is, That a *Diamond* being *rub’d, struck* or *heated* in the dark, shines for a pretty while after, so long as that motion, which is imparted by any of those Agents, remains.” Ibid.

vibrations are short.

After going on at quite a bit more length about the nature of light and optical phenomena, Hooke at last returns to the crucial experiment, first repeating the negative conclusion and then moving on to the affirmative one:

Upon the calculation of the refraction and reflection from a Ball of Water or Glass, we have much the same *Phænomena*, namely, an *obliquity* of the undulation in the same manner as we have found it here. Which, because it is very much to our present purpose, and affords such an *Instantia crucis*, as no one that I know has hitherto taken notice of, I shall further examine. For it does very plainly and positively distinguish, and shew, which of the two *Hypotheses*, either the *Cartesian* or this is to be followed, by affording a generation of all the colors in the Rainbow, where according to the Cartesian Principles there should be none at all generated. And secondly, by affording an instance that does more closely confine the cause of these *Phænomena* of colours to this present *Hypothesis*.³¹

The statement that the crucial experiment merely “closely confine[s]” the hypothesis to Hooke’s is in line with my reading of Bacon. Recall that Bacon too allows for crucial experiments which affirmatively establish the genus of a nature, leaving it up to future investigation to establish the differentiae. Hooke thinks he can establish that the colors are caused by pulses or waves that are at right angles to the forward motion of the light (in the same way as the peaks and troughs in the ocean are at right angles to the direction of the water’s motion).

The argument for that conclusion is technical and would take us too far afield, especially since it is probably unsuccessful, in the end. But Hooke’s other crucial experiment, it is easy to see, has some promise. It is his attempt to measure stellar parallax.

Long before Hooke, Galileo had conceded that a weakness of the Copernican hypothesis was that it predicted that we should see the stars shift their relative positions in the sky as the earth moved around the Sun over the course of the year. This is a phenomenon called stellar parallax, and the failure to detect it meant that astronomers had to choose: either reject Copernicus, or accept that the universe is large enough to render stellar parallax negligible. Galileo chose the

³¹Ibid.: p. 59

latter option, but many others found it difficult to believe that the stars were that far away.

Robert Hooke, like Galileo, believed that the Copernican hypothesis was very probably true. The Ptolemaic theory had already been eliminated by Galileo's discovery of the phases of Venus, and the alternative Tychonic hypothesis was *ad hoc* and did not make much sense from a causal point of view. But Hooke did not believe that this inference to the best explanation was enough to provide certainty. So he conceived of a crucial experiment to settle the question once and for all: the detection of stellar parallax (see Figure 6.2.2).

Whether the Earth move about the Sun, or the Sun about the Earth; and all the Arguments alledged either on this or that side, are but probabilities at best, and admit not of a necessary and positive conclusion. Nor is there indeed any other means left for humane industry to determine it, save this one which I have endeavoured to make; and the unquestionable certainty thereof is a most undeniable Argument of the truth of the Copernican System; and the want thereof hath been the principal Argument that hath hitherto somewhat detained me from declaring absolutely for that Hypothesis, for though it doth in every particular almost seem to solve the appearances more naturally and easily, and to afford an exceeding harmonious constitution of the great bodies of the World compared one with another, as to their magnitudes, motions, and distances, yet this objection was alwayes very plausible to most men, that it is affirmed by such as have written more particularly of this subject, that there never was any sensible Parallax discovered by the best observations of this supposed annual motion of the Earth about the Sun as its center.³²

Hooke explains that others before him did not have the requisite telescopes to perform this crucial experiment:

For all Observators having hitherto made use of the naked eye for determining the exact place of the object, and the eye being unable to distinguish any angle less then a minute, and an observation requisite to determine this requiring a much greater exactness then to a minute, it doth necessarily follow that this *experimentum crucis* was not in their power.³³

³²Hooke, *An Attempt To prove the Motion of the Earth from Observations*: pp. 4-5.

³³*Ibid.*: p. 4.

Others also lacked a solid understanding of the laws of optics. Hooke recognized that the atmosphere bends the incoming stellar light, and the more oblique the angle of the incoming light, the greater the refraction. He realized, though, that this confounding variable could be mitigated by selecting a star at the zenith—and it so happened that the star Gamma Draconis passed near enough to the zenith over his Gresham College apartment. Training his telescope on Gamma Draconis had the further advantage, as he imagined it, that it would be easier to keep the telescope fixed in place. He needed only to keep the telescope parallel to a plumb bob.

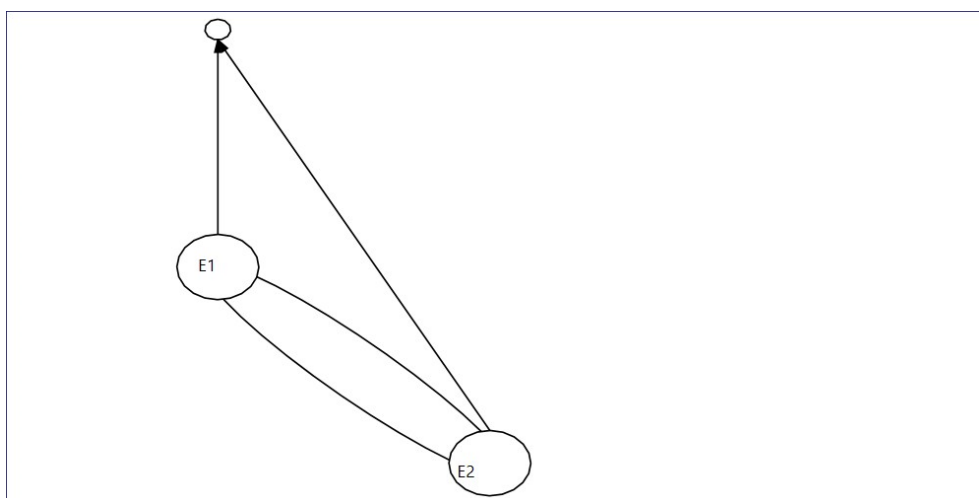


Figure 6.3: The Detection of Stellar Parallax

If the Earth moves around the Sun over the course of the year, then a star which is at the zenith when Earth is at E1 should be displaced from the zenith at E2. Note that the closer the star is to the earth, the more dramatic the change in the perceived location will be. Since the stars are so far away, the effect is much more minute than depicted here.

So Hooke watched and waited, hoping to see Gamma Draconis shift position cyclically over the course of the year. As ingenious as the setup was, Hooke found that the precision of his measurements was still limited:

I often found that when I came to examine the Instrument, a day, or two, or three, or more, after a former observation, that there had been wrought a considerable change in the Perpendiculars, in so much as to vary above a minute from the place where I left them, which I ascribe

chiefly to the warping of the Tube that rose above the roof of the House, finding sensibly that a warm day wou'd bend it considerably towards the South, and that a moist Air would make it bend from the quarter of the wind: But yet I am apt to think there might be somewhat also of that variation ascribable to the whole Fabrick of the Roof, and possibly also to some variation of the Floors; but yet I never found these variations so sudden, as to be perceptible in the time of a single observation, finding alwayes the preceding and subsequent adjustings to answer.³⁴

Despite these unforeseen complications and still others besides them, Hooke eventually pronounces his conclusion:

'Tis manifest then by the observations of July the Sixth and Ninth: and that of the One and twentieth of October, that there is a sensible parallax of the Earths Orb to the fixt Star in the head of Draco, and consequently a confirmation of the Copernican System against the Ptolomaick and Tichonick.³⁵

Perhaps because of the complications, he calls his results a “confirmation,” which sounds rather weaker than the absolute certainty he was aiming for. But for my purposes, what is interesting about this experiment is that Hooke believed that the ability to make more exact measurements *would* have enabled him to decide in favor of the geokinetic theory with absolute certainty.

Even if one overlooks the technical difficulties, one might object that the parallax could have two explanations. Either the earth moves, or Gamma Draconis does. Indeed, there were geocentric theorists, such as Athanasius Kircher (1602-80), who did not hesitate to point this possibility out preemptively. Of course geostatic theorists of the time *usually* held that the stars were fixed in position relative to one another. They were all equally subject to the daily motion of the stellar sphere and to the precession of the equinoxes (thought of as a wobbling of the stellar sphere), which affects all of the fixed stars equally. Defending a geostatic theory, while compatible with the observation of the the kind of stellar parallax Hooke was searching for, would require adding another motion to the fixed stars on top of these two, and depending on the measurements it might require adding

³⁴Hooke, *An Attempt To prove the Motion of the Earth from Observations*: p. 23.

³⁵Ibid.: p. 25.

different motions to different stars. The necessary modification of the Tychonic system would be *ad hoc*. But if these were grounds enough to decide in favor of Copernicus, then the long history of *ad hoc* adjustments to geostatic astronomy would have already been sufficient for Hooke's purposes.

It is difficult to say why Hooke is not troubled by this line of thought. I would be inclined to say that Hooke departs from Bacon's understanding of crucial instances and holds that they need only decide between prevailing hypotheses as formulated at the time, were it not that he objected to Newton's crucial experiment, refusing to even call it a crucial experiment, on the grounds that other *conceivable* hypotheses could explain the phenomena. He also says that the goal of his crucial experiment is to establish a "necessary and positive conclusion," harkening back thereby to Bacon's language about affirmatives. What is he thinking?

Here are a few possibilities. First, perhaps Hooke sometimes overused Baconian rhetoric. This would be interesting sociologically, but perhaps a dead end philosophically. Second, perhaps Hooke had a temporary lapse of scientific judgment. Again, this would be philosophically uninteresting, though it might shed light on Hooke the human being. But here is a third, more charitable possibility. Perhaps Hooke is implicitly appealing to background knowledge about the cause of heavenly motions. If Hooke could be certain that attractive forces were the cause of orbits, then perhaps he had some dynamical justification for ruling out empirically equivalent geostatic hypotheses to explain the stellar parallax.

If this third thought is what Hooke has in mind, then I think the crucial experiment that he conceives of is a worthy illustration of what Bacon aims for. Unfortunately for Hooke, it was too early in the history of science to pull off the crucial experiment successfully; the requisite technical skill and background knowledge were not yet at the level where they needed to be. But given the measurements of stellar parallax in the 19th century, in conjunction with our current background knowledge, a modern Baconian would not have to be naive to hold with certainty that the Earth is in motion.

6.3 Summary of the Dissertation

This concludes my interpretation and defense of Bacon. I mentioned when I started that one of my goals was to challenge the idea that induction must be defined as a method in which the premises render a conclusion probable, such that there is some risk that the premises can be true while the conclusion is false. Now that Bacon's method, including many of his resources for justifying claims about formal causes, is on the table, it is worth reflecting once again on the difference between deduction and induction.

But first, let me review the groundwork that I have laid one last time. I began by showing, based on the fact that Bacon is critical of skeptical positions that allow for moral certainty, that he aspires instead to epistemic certainty about formal causes (see Chapter 2). In contrast to probable beliefs, epistemically certain beliefs are justified beyond a reasonable doubt. (As Chapter 3 specifies, justification beyond a reasonable doubt means that there are no potential defeaters which are compatible with the assumption that we live in a causal world, or a world where there is no change in the reports of sense-perception without a corresponding change in a mind-independent object). I also argued that this sort of epistemic certainty is not restricted to Part Six of the *Instauratio*. The reason some readers have been confused about this is because Bacon argues that "certainty" is one of the key desiderata of the rules of operation that belong in Part Six. But as I showed, some rules can be certain in the sense of stating universal predications without being conclusively justified (the efficient causes that occupy the domain of physics can have this property), and some beliefs can be conclusively justified without stating universal predications. Indeed, it is now clear that most of natural history should, according to Bacon, eventually have this status.

In Chapter 3 I turned to the basis of natural history, sense-perception. I showed that Bacon has the resources to respond to reasons for doubt rooted in questions about the veracity of sense-perception. On his view, which is basically an atomist one, the immediate objects of sense-perception are mind-independent objects (so he is a direct realist), sense-perception is *alogos* and therefore cannot be blamed for errors made by the intellect, and all sense-perceptions are true. I

showed that his project of offering atomist explanations for illusions and hallucinations can defuse those skeptical arguments against the senses which are rooted in the phenomena of illusions and hallucinations. I also showed that, for Bacon, the truth of sense-perception consists in its registering differences and changes in the world, such that a false sense-perception could arise only if there were a breach of causality, a change in the reports of sense-perception without a corresponding change in a mind-independent object. It is true that we cannot prove, but rather have to assume, that we live in a causal world and that we can detect differences and changes among mind-independent objects. This realist assumption is indeed a source of risk that will carry on up to the conclusions of inductive arguments. But as Bacon argues, the skeptical attitude towards sense-perception has terrible practical consequences. Therefore, sense-perception remains true beyond a *reasonable* doubt.

Then in Chapter 4, I argued that Bacon's adoption of moderate foundationalism allows him to explain how it is possible to begin with strongly justified notions and beliefs based on sense-perception which, though they may not be epistemically certain at first, can be further justified by later beliefs. We saw two kinds of revision mechanisms which accounted for Bacon's embracing the possibility of progressively increasing degrees of certainty throughout natural history. First, we saw that both literate experience and the Interpretation of Nature allow for the continuing enhancement of natural histories. And second, we saw that beliefs about causes reached by the Interpretation of Nature (whether those beliefs are probable or certain) could be used for the purposes of correcting instances in a natural history, thereby minimizing the possibility of lasting errors. I also discussed Bacon's distinction between pure and impure natural histories. Impure histories are those which contain non-historical material, such as discussions of causes and axioms. Pure histories are those which contain a body of factual information about a phenomenon. I showed that Bacon's own natural histories are impure and that the discussions of causes and axioms are there, in part, as part of the aforementioned processes of revision and self-correction. Ultimately, though, Bacon aspires for pure natural histories. While those pure histories must still be justified by the

generative process that gave rise to them (or by a possible or idealized generative process), given Bacon's belief that justification must follow a possible path of discovery, the idea is supposed to be that these pure histories can at some point become justified beyond a reasonable doubt and be used as a certain foundation for the method of induction.

On the assumption that such a foundation is possible, Chapter 5 argued that we have no good reasons for thinking that the results of Baconian induction must lose any of the certainty possessed by that foundation. I focused on three reasons for doubt, all of them rooted in the straw man portrayal of Bacon's method as one of eliminative induction: that Bacon cannot justify a list of all the possible formal causes for a type of phenomenon, that falsifying those possibilities based on his tables of instances must also rely on auxiliary assumptions which might be open to question, and that he cannot justify the extrapolation from some instances of a phenomenon to all instances of a phenomenon because we sometimes make mistakes about whether two instances should be regarded as of the same kind, in the sense of possessing the same form.

My overarching response to these reasons for doubt is that the method of elimination is only one of Bacon's techniques and is hardly the weightiest source of justification for axioms about formal causes. In what might be the ideal case, the method culminates in crucial instances, the best of which proceed not by falsifying alternatives but by directly affirming the true cause, or part of the true cause, of a nature.

In response to the concern about the impossibility of a finite list of possible formal causes, I made two more specific observations. First, the manner in which the method of elimination works is more sophisticated than it has been characterized to be. For example, it is tied up with an Aristotelian method of division. Second, by means of migratory instances, Bacon does in fact have a way of justifying a premise which narrows down the space of possible formal causes.

In response to the concern about the role of auxiliary assumptions, I noted that this argument begs the question against Bacon's foundationalism. Furthermore, Bacon is in fact sensitive to the interconnectedness of different inquiries with

each other; that is why he advocates a modular approach to inquiry where preliminary results may be stated conditionally, subject to the further examination of the “links” with other inquiries that should be set down in writing.

And in response to the concern about extrapolating from causes of singular instances to causes of types of instances, I noted the role of the prerogative instances that relate in one way or another to “cutting nature at the joints.” These instances provide Bacon with some resources either to justify or to correct claims that we are genuinely latching onto a type of phenomenon, when seeking the formal cause of a nature.

I concluded in this chapter by examining the crucial experiments of Newton and Hooke and suggesting a revision to Bacon’s method based on Newton’s fourth rule of reasoning. Newton and Hooke both use crucial experiments to decide in favor of a theory which we still hold to be true today and thereby provide us with a worthy illustration of what Bacon’s method, at its best, might look like in practice. Bacon unfortunately neglects to notice the need for something like Newton’s fourth rule, and this is due to Bacon’s mistaken principle of limited variety, which says that there are a finite number of simple natures in the universe. Since we can never be assured that we have the full range of facts on offer in the universe, we must always allow for the possibility of further revisions to our beliefs.

With this groundwork having been laid, consider once again the difference between deduction and induction. In deductive arguments, the premises necessitate the conclusion, such that if the premises are true, then the conclusion must be true. But there is still the risk of making a mistake about whether the premises necessitate the conclusion, and there is still the risk that arises from any uncertainty in the premises. Induction has the same set of risks. The difference between induction and deduction, with respect to the question of necessity, is that denying the conclusion of an inductive argument never results in a formal contradiction. That much remains true even on Bacon’s conception of induction.

But it is not true, on Bacon’s conception, that *this* difference must result in any additional risk to the conclusions that are reached by means of induction. Bacon’s aim—which is most plausibly realized by Newton in his prism experiments

and by the use of stellar parallax to prove that the Earth is in motion—is for inductive arguments the conclusions of which can be coherently denied only by failing to bear actively in mind everything else one knows.

To illustrate, consider how a Baconian might defend the certainty of the view that the Earth is in motion on the basis of the argument from stellar parallax. What could make it reasonable to doubt the conclusion? Could we be ignorant of some factor in the Earth's atmosphere which causes the stellar light to appear to shift? Is that a potential defeater? Perhaps Hooke, working in an era with less knowledge about optics and about atmospheric phenomena, should have entertained that possibility more seriously, but we know enough today to be able to rule it out. That argument, of course, would depend on still prior background knowledge. For example, perhaps we base our judgment partly on our analysis of the composition of the atmosphere and the properties of the gases involved. In that case, continuing the regress, there is even earlier background knowledge about the instruments we have employed to make measurements. And that background knowledge depends on still prior knowledge, and so on. If Bacon's foundationalism is correct, then eventually we should arrive at properly basic beliefs, such as "This light bends." This is just one of many beliefs in which this regress might terminate. At that point, especially given the additional justification offered by the processes of enhancement and self-correction, how can one question the belief except perhaps by going still deeper to the level of notions? But then, in turn, how can we question our ability to distinguish that which is bent from that which is not bent, unless we deny the power of sense-perception to detect such similarities and differences? And if Bacon's account of sense-perception is correct, the only way sense-perception can lack this power is if the world allows for the non-causal, in the sense specified by Chapter 3.

The basic pattern is as follows. In denying beliefs that are justified inductively beyond a reasonable doubt, we will find that one of two things happen. We might try to justify that denial, in which case we will have to make radical revisions to our worldview to accommodate it. The mark of a belief that is justified beyond a reasonable doubt is that these revisions will redound all the way

down to the foundation and force us to deny that our senses have the power to detect differences among things in the world. Second, alternatively, we might deny these conclusively justified beliefs without citing a specific justification, just on the grounds that we might be ignorant of a confounding factor. But this objection is not a source of reasonable doubt, and in fact a skeptical attitude which is that radical would be just as much—or just as little—a threat to the conclusions of at least some deductive arguments. After all, there are many mathematics problems which are difficult enough that such a skeptic could semi-plausibly allege, without citing any specific grounds, “Maybe you’ve made a mistake somewhere along the line. After all, mistakes happen.”

Do not forget that, if we are following Bacon, then our scientific method itself should be discovered and justified inductively and subject to Bacon’s revision mechanisms; and if one also follows the considerations in this chapter, then one will want to add *ceteris paribus* clauses to any principle, including the principles of scientific method. If, for example, there are grounds for reasonable doubt that I have not considered, or if somehow it could be demonstrated that sense-perception lacks the difference-detecting power that Bacon ascribes to it, or that there are special kinds of cases where sense-perception lacks that power, then a number of revisions and corrections would be made necessary or the exceptions would have to be specified. In short, Bacon has reasonable grounds for thinking that certainty about formal causes is possible, but those grounds themselves are not fully certain. I imagine that Bacon, like myself, would welcome corrections.

Appendix A

Guide to the Prerogative Instances

It is an interesting question why the latter half of the *Novum organum* is structured the way it is, but one thing is clear: it is not designed for ease of reference. The prerogative instances are neither grouped according to important similarities nor consistently ordered based on their fundamentality or importance. In addition, sometimes Bacon's examples go on at such length that one tends to lose sight of the larger context. The fact that some of the instances are subject to lengthy questions of interpretation also hinders in the effort to integrate each one of them into my overall interpretation of Bacon's method.

I suspect that this lack of apparent structure is deliberate; Bacon argues elsewhere that such esotericism can promote independent inquiry and serve as an antidote to dogmatism. But this will not do when we are aiming for clarity about Bacon's method. Since this dissertation has had to make reference to the prerogative instances across diverse contexts, the reader may find it useful to consult this "Guide to the Prerogative Instances" as needed, or to read it in its entirety in order to get a bird's-eye view of them.

I have designed it for ease of reference, as a sort of handbook. For each instance, I have included information about what it is, what function or functions it serves, different subcategories if there are any, ways of distinguishing the instance from others with which it might be confused (if applicable), and any other places

in Bacon's work with which the instance should be compared (if applicable). Individual prerogative instances are followed in brackets by Bacon's own numbering in Part II of the *Novum organum*, whereas the way I structure them is based on the taxonomy outlined in the very last aphorism of the *Novum organum*.

The broadest division among the prerogative instances is that between (A.1) the instances that are primarily directed towards the aim of supplying information and (A.2) the instances that are primarily directed towards assisting in the operative part of science. I will discuss the informative instances first.

A.1 Informative Instances

The informative instances are further subdivided into (A.1.1) the instances that supply information related to sense perception, which are the Instances of the Lamp, and (A.1.2) the instances that supply information to the intellect.

A.1.1 Instances of the Lamp

Five of the prerogative instances fall under the heading of Instances of the Lamp. These instances all have the same **function**, which is to supply information that is related to sense-perception. It is important to note that these instances are **primarily used in the development of natural history**.

Gateway Instances or Instances of Access (*ianuae*) [16] The **function** of Gateway Instances is to strengthen, enlarge, or rectify the information supplied by sense perception. There are three kinds of Gateway Instances corresponding to those three variations in function:

- Those which report sensory information about what is **by nature unobservable**, that is, unobservable because of the kind of thing that it is. An example is an observation with a microscope.
- Those which report sensory information about what is unobservable by virtue of its **distance**. An example is an observation with a telescope.

- Those which report sensory information about what is observable with **greater precision and distinctness**. Examples include observations with compasses, protractors, and astrolabes.

Summoning Instances (*citantes*) or Evoking Instances [17] The **function** of summoning instances is to supply information about imperceptible things by finding perceptible things that testify about them. These differ from gateway instances in that whereas gateway instances actually expand our powers of observation by providing us with new things to observe, these leave our powers of observation unchanged and rely on **semiotic inference** from what we already had the power observe. An example is the observation of someone’s pulse. The heartbeat is unobserved, but we can use the observed pulse as a sign of what is going on internally.

Instances of the Pathway or Instances En Route (*itinerantes*) or Step-By-Step Instances (*articulatas*) [18] The **function** of Pathway Instances is to supply information about unobserved or unobservable **steps in a process**. Thus, these are important for discovering axioms about latent processes. An example of a Pathway Instance is observing the growth of a plant by digging up seeds at one day of growth, two days, three days, etc.

Supplementary Instances or Instances of Substitution or Instances of Refuge [19] These are foreshadowed by Bacon in I. 69 of the *Novum organum* when he says that “the desertions of the senses need substitutions.” Supplementary Instances have two distinct **functions**:

- they supply information when no instances are available, i.e., they serve as substitutions when sense perception **deserts or abandons us**;
- they **corroborate** the results of an induction by supporting it with an instance that the induction did not originally depend on. Bacon associates this second, corroborating function with the unwritten part of the *Novum organum* that was to be called the Supports to Induction.

There are two kinds of Supplementary Instances:

1. **Substitution by degrees:** If there is no instance where the nature being investigated is completely absent, substitute an instance where the nature is present to a very low degree. For example, we might use something extremely cold instead of something that lacks any heat at all.
2. **Substitution by analogy:** If we are missing an instance that we would like to have, we can substitute an analogous instance. For example, suppose we want to know what happens when air mixes with flame. We never see that happen, but flame is like oil and air is like water, so we can substitute for the instance which we lack the imperfect mixture of oil and water in the blood.

Dissecting Instances or Prompting Instances or Democritean Instances [20] The **function** of Dissecting Instances is to help discover things that are subtle, meaning that they are fine-grained or relate to the microscopic structure of bodies. **Limits of Dissection** (instances where something subtle cannot be observed because it is drowned out) are subjoined to these and associated by Bacon with the unwritten part of the *Novum organum* called **Supports to Induction**.

A.1.2 Instances Informative to the Intellect

Whereas Instances of the Lamp are conceived of as aids to sense-perception, the following instances are conceived of as aids to the intellect in the work of induction. Note that a single instance might be an Instance of the Lamp in one respect and an instance informative to the intellect in another. For instance, one might discover a strange planet by means of the telescope. That instance would then be an Instance of the Gateway insofar as it presents to us something that is otherwise unobservable by virtue of its distance and a Deviating Instance insofar as it is an abnormal instance of its kind. I will divide instances informative to the intellect into (A.1.2.1) those that should be pursued as soon as one starts to put together a natural history and (A.1.2.2) those that should be pursued only later as part of the method of induction.

A.1.2.1 Instances with a Preparative Function (in the creation of a natural history) as well as an Inductive Function

Instances of Correspondence (*conformes*) or Proportionate Instances or Parallels or Physical Resemblances [6] The **function** of Instances of Correspondence is to assist in discovering axioms about the configuration of the world. The instances have the following **schema**: particular thing A resembles particular thing B. For example, the observation that the mirror resembles the eye is an instance of correspondence.

Bacon does even more with this example: mirrors and eyes are of like nature, but they differ in respect of consciousness. Therefore, he says, we can infer a new axiom: spirit is what makes something with that nature conscious. This example seems to involve the **joint application** of Instances of Correspondence with Solitary Instances (see A.1.2.2). Thus, this example is important more generally as evidence that the prerogative instances might be able to work in conjunction with one another in other cases as well.

Monadic Instances or Irregular Instances or Heteroclitite Instances [7]

These are monstrous or unique species of things and have their place in the history of pretergenerations (the part of natural history that deals with unusual or irregular instances).¹ An example of such a unique species is the magnet (within the genus of stones). The **function** of monadic instances is to assist in discovering genera and to help battle habitual thinking.

Deviating Instances [8] These are monstrous or unique individual instances and also have their place in the history of pretergenerations. An example is a particular set of conjoined twins. These types of instances serve two **functions**, the first of which is identical to the function of monadic instances: they are useful for making sure one's definition of a species is broad enough and for battling habitual thinking. Second, they are useful for discovering the latent process that causes a form. This latter function is a result of the fact that seeing the process

¹See *De augmentis*, Vol. 4, pp. 294-5.

that causes an individual to go astray, in comparison with other members of the same kind, can sometimes help identify whatever process is normal in that kind.

Frontier Instances (*instantias limitaneas*) or Participles [9] Frontier instances are instances of a species that are borderline cases between two other species. Their **first function** is to assist in discovering the composition and structure of things. Their **second function** is to assist in discovering the causes of the number and quality of ordinary species. Their **third function** is to assist in discovering natures that can be compounded and thereby produce new combinations of natures that don't yet exist. It is worth mentioning that these are a special case of monadic instances.

Instances of Power or Instances of Fasces or Instances of Ingenuity or Instances of the Hand of Man [10] These are noteworthy inventions and works of craft and art. Their **function** is to serve as useful material for literate experience.

A.1.2.2 Instances With a Primarily Inductive Function

Solitary Instances or Ferine Instances [1]: The function of solitary instances is to speed up the eliminative process. As I have discussed in Chapter 5, Bacon's discussion of Solitary Instances is difficult to interpret. I here present my own preferred reading. There are two kinds of Solitary Instances:

Instances solitary in respect of resemblance: One finds two radically different instances which, despite their differences, share a nature in common. Many accounts of the cause of the nature can thereby be ruled out, since many accounts will presumably appear to succeed for one of the instances but fail in relation to a radically different instance.

Instances solitary in respect of lack of resemblance: One finds two instances which are very similar to one another but which, despite their similarity, have different natures. These instances allow one to make the following sort of

argument (although I want to resist the implication that Bacon sees a need to conform to this schema exactly):

(A.1)

- (1) Kind of body with properties A, B, C has nature N.
- (2) Kind of body with properties A, B, C lacks nature N.

∴ (3) Therefore, neither A, B, nor C are the cause of N

Solitary instances are sometimes identified or associated with Mill's Methods of Agreement and Difference.²

Migratory Instances [2]: The **function** of migratory instances is to narrow down the domain of possible formal causes. These have roughly the following **schema**: Body at Time 1 lacks/has Nature N. An efficient cause acts on the body. Body at Time 2 has/lacks Nature N (or has it to a different degree). Therefore, the formal cause of nature N is among the natures which were introduced or destroyed by the efficient cause. An example is the introduction of the nature of whiteness to water by means of the frothing caused by a violent wind. This instance tells us that the formal cause of whiteness is among the natures which can be introduced to water by a violent wind.

Note that Fowler wrongly associates migratory instances with Mill's Methods of Concomitant Variation and Difference. Bacon's inference here is mediated by background knowledge about the efficient cause in question.

Indicative [*ostensiuas*] Instances or Shining [*elucescentias*] Instances or Liberated Instances or Predominant Instances [3]: These are instances of a nature in which that nature is particularly evident either because there are few impediments to restrain it or because that nature is particularly strong. Their

²See the commentary in Francis Bacon. *Novum organum*. Ed. by Thomas Fowler. Clarendon press, 1878: pp. 415-16, nn. 34-5.

function is to assist in discovering either the genus or the differentiae (but especially the differentiae) when working on a definition of a form; they are useful in arriving at a First Vintage, but more rigorous methods are needed later on because these instances only provide a weak degree of justification. Bacon implicitly relies on indicative instances at every step of the way when defining heat. He says that its genus (motion) is indicated [*ostenditur*] most clearly in flame.³ He says that the first among the differentia is expansiveness, and that this is indicated [*ostenditur*] by boiling liquors, among other things. He continues to use indicative instances to support his claims about all of the remaining differentiae as well.

Clandestine Instances or Twilight Instances [4]: These are the opposite of indicative instances; they are instances in which the nature is particularly subdued. Their **function** is to assist in discovering the genus of a form by making sure that a proposed genus is broad enough to cover all the instances, including those at the edge of the category.

Constitutive Instances or Collective [*manipulares*] Instances [5]: These instances roughly fit the following **schema**: $P^1, P^2, P^3 \dots P^n$ all have Nature N. P^1 and P^2 belong to a common species that can be defined as D^1 . P^3 and P^4 belong to a common species that can be defined as D^2 . The **first function** is to assist in the discovery of the formal cause by means of partial unification. The **second function** is to assist in dividing nature at the joints.

Instances of Fixed Propositions [11]: This instance is further divided into:

Instances of Companionship: These are instances in which the nature is constantly conjoined with a particular kind of body. Their **function** is to allow us to use enumerative induction to support universal affirmative propositions, which may then be added to a natural history's table of presence.

³*N.O.* II. 20: 2A4^V.

Instances of Hostility: These are instances in which the nature is constantly excluded. Their **function** is to allow us to use enumerative induction to support universal negative propositions, which may then be added to a natural history's table of absence.

Subjunctive Instances or Instances of an Ultimate State or Limit [12]:

These are instances in which any further increase or decrease of some nature in the thing would render that thing different in kind. A **first function** is that these should be subjoined to instances of fixed propositions [11] in order to indicate their limits. A **second function** is to aid in dividing nature at the joints, i.e., in specifying the range in which a nature can be present without changing the kind of thing something is. For example, gold is the densest thing we can find, while spirit of wine is the least dense. Our notion of density will therefore have to be broad enough to cover everything within that range, from least dense to most dense. A **third function** is to indicate the transitions of one nature into another. For example, silk worms are the smallest animals, yet some organisms are smaller than silk worms. Therefore, we need a new notion (e.g., of bacteria), and we should note the natures that bacteria have in common with animals and the differing ranges in which those natures are present in animals as against bacteria.

Instances of Alliance [*foederis*] or Union [13]: These are instances which provide grounds for subsuming two instances under the same genus, when previously they were thought not to have a common genus. Their **function** is to assist in the discovery of the genus by abolishing false distinctions. The instances involve looking for essential similarities between the two instances.

Instances of Divorce [15]: These instances have roughly the following pattern: Natures N^1 and N^2 frequently occur together. But they can also exist separately from each other. Therefore, neither nature is part of the form of the other. The **function** of these instances is to help us discover when a proposed statement of a formal cause includes some nature that, although perhaps frequently associated with the nature under investigation, can also exist separately from it.

Crucial Instances or Decisive or Judicial Instances or Instances of the Oracle or Instances of Instruction [*mandati*] [14]: These instances fit the following pattern: During the course of an inquiry into the form of a nature N, one may either hypothesize or know that the formal cause is (or is a specification of) one of two or more natures. A crucial instance is one that eliminates, or strongly suggests the elimination of, all of those possible causes but one. It might do so by means of falsifying the other possible causes, or it might do so affirmatively and falsify any other possible causes by means of that affirmation of the true cause. Crucial instances can have the **function** of either guiding further inquiry or of proving a claim about a form with certainty. See Chapters 5 and 6 for a fuller discussion of crucial instances.

A.2 Instances Primarily Directed Towards Operation and Practice: Practical Instances

A.2.1 Instances with a Preparative Function (in the creation of a natural history) *and* Inductive Function: Propitious Instances or Benevolent Instances

Three of the prerogative instances fall under the heading of propitious or benevolent instances. What they have in common is that they suggest easier or more productive experiments of fruit or light.

Intimating [*innuentes*] **Instances** [25]: These are instances which correspond to some item on a list of desiderata related to a particular investigation and point to possible ways of making progress towards it. Their **function** is to maximize the efficiency of an investigation by directing the investigator's focus to things that offer the most promise at fulfilling our needs. For example, Bacon's *Historia ventorum* contains "A Table of Human Goods, or Desiderata with their Closest Approximations, concerning the Winds" which indicates, among other things, that we should look to an earlier portion of the work that discusses the instance of bird

flight, in order to learn how to build better windmills and sails.⁴

Multi-Purpose Instances [26]: These are instances that are frequently useful in the course of the operative part of science.

Magical Instances [27]: These are instances in which a comparatively small or weak material or efficient cause produces a great effect. There are four typical kinds (although Bacon notes that the fourth is speculative and may not exist):

- instances which work by means of self-multiplication (e.g., fire),
- instances which work by means of gears,
- instances which work means of powers that can act on other bodies without being reduced (e.g., magnetism),
- instances which work by means of the manipulation of bodies on a corpuscular scale.

A.2.2 Practical Instances With a Primarily Inductive Function: Mathematical Instances or Instances of Measure

These instances all involve precise measurement and are distinguished from each other by differences in the kind of attribute being measured. Their practical function is a result of the fact that successful experimentation sometimes requires careful measurement.

Instances of the Measuring Rod or Ruler or Instances of Stopping Off or Instances of Thus Far and No Further [21]: These are instances which allow for the measurement of distance.

Instances of the Race-Track or Instances Run by Water [22]: These are instances which allow for the measurement of time.

⁴Bacon, *The Instauration magna: Part III: Historia naturalis*: R1^r.

Instances of Quantity or the Doses of Nature [23]: These are instances which allow for the measurement of quantities and proportions.

Instances of Wrestling or Instances of Ascendancy [24]: These are instances which help with the ordinal ranking of virtues from least to most powerful.

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