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Bacon's metaphysical method

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In this paper, I would like to examine the method that Bacon proposes in *Novum organum* II.1-20 and illustrates with the example of the procedure for discovering the form of heat. One might think of a scientific method as a general schema for research into nature, one that can, in principle, be used independently of the particular conception of the natural world which one adopts, and independently of the particular scientific domain with which one is concerned. Indeed, Bacon himself suggested that as with logic, his method, or as he calls it there his "system of interpreting" is widely applicable to any domain, and not just to natural philosophy. [*Novum organum* I.127] Now, recent studies of Bacon have emphasized his own natural philosophical commitments, and the underlying conception of nature that runs through his writings. In my essay I argue that the method Bacon illustrates in *Novum organum* II is deeply connected to this underlying view of nature: far from being a neutral procedure for decoding nature, Bacon's method is a tool for filling out the details of a natural philosophy built along the broad outlines of the Baconian world view.

Keywords: Francis Bacon, method, experiment, natural history, induction, Karl Popper, methodological *a priori*

Метафизический метод Бэкона

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В этой статье анализируется метод, который Ф. Бэкон излагает в начале второй книги «Нового Органона» и который он иллюстрирует на примере процедуры открытия формы тепла. Научный метод обычно рассматривается как общая схема исследования природы, применение которой не должно зависеть от особенностей концепции природы, которую принимает исследователь, и независимо от конкретной научной области. Действительно, сам Бэкон полагает, что, подобно логике, его метод, или, как он его называет, «система интерпретации», широко применим к любой области, а не только к натурфилософии [Novum organum I.127]. В последнее время в фокусе исследований наследия Бэкона находятся его собственные натурфилософские убеждения и предполагаемая концепция природы, которая проходит через все его труды. В своем эссе я утверждаю, что метод, который Бэкон излагает во второй книге «Нового Органона», глубоко связан с этой основополагающей концепцией природы: не будучи нейтральной процедурой расшифровки природы, метод Бэкона является в первую очередь инструментом уточнения деталей натурфилософии, построенной в соответствии с базовыми характеристиками бэконовского мировоззрения.

Ключевые слова: Фрэнсис Бэкон, метод, эксперимент, естественная история, индукция, Карл Поппер, методологическое априори

There is a certain idealized view of scientific method, what it is and what it is supposed to do. A good scientific method should be neutral in at least two respects. First of all, it should be free of substantive assumptions about the way the world is. What we find by using a method should, of course, depend on the way the world is, but, at the same time, it shouldn't be dependent on what we may happen to think that the world is like, prior to empirical investigation. And second, a good scientific method should be applicable to any domain of inquiry we like, and not limited to one or another limited domain. These constraints are satisfied, for example, by the text-book presentation of the inductive method that Ernan McMullan articulated:

> One begins from the observation of singulars, noting the regular cooccurrence of certain features, and generalizes to a lawlike statement relating these features to one another in a stable way. The inference takes the form of *generalization*. One moves to a claim about a class as a whole from the evidence of a sample. Regular co-occurrence is taken to be a sufficient (and perhaps, indeed, the only legitimate) basis for asserting a "lawlike" relationship. Science itself is taken to consist exclusively of "laws" arrived at in this way [McMullin, 1990, p. 30].

One might think that this is what Bacon has in mind for the famous method that he puts forward in his *Novum organum* (1620). In a celebrated passage in the *Novum organum*, Bacon wrote:

> Those who have dealt with the sciences have either been empirics or dogmatists. The empirics, in the manner of the ant, only store up and use things; the rationalists, in the manner of spiders, spin webs from their own entrails; but the bee takes the middle path: it collects its material from the flowers of field and garden, but its special gift is to convert and digest it. The true job of philosophy is not much different, for it depends not only or mainly on the powers of the mind, nor does it take the material gathered from natural history and mechanical experiments and store it unaltered in the memory but lays it up in the intellect changed and elaborated [Bacon, *Novum organum* I.95][1].

The suggestion is that in the true method, the method of the bee, the investigator begins with the material gathered from nature, the natural histories, but converts and digests it to produce something transformed, like the honey the bee produces. Or, to put it somewhat less metaphorically, as Bacon does in the *De augmentis scientiarum* (1623):

> For knowledges are as pyramids, where of history and experience are the basis. And so of Natural Philosophy the basis is Natural History;

[1] References to the *Novum organum* are given in the text by book number followed by aphorism number; for some of the longer aphorisms, I will also give the page number in [Bacon, 1996–, vol. XI]. The translation used is by Graham Rees, which can be found in [Bacon, 1996–, vol. XI], with the Latin original on facing pages.

> the stage next the basis is Physic; the stage next the vertical point is Metaphysic [Bacon, *De augmentis scientiarum* III.4: Bacon, 1858-74, vol. I, p. 567, trans. in vol. IV pp. 361–362].

Furthermore, Bacon claims, his method is not limited to natural philosophy, as the examples he discusses in the *Novum organum* might suggest, but is applicable in principle to all of the other sciences:

> Someone will also put it forward as a doubt rather than an objection, whether I speak of natural philosophy alone, or whether I also speak of perfecting the other sciences-logic, ethics, and politics-by taking the route I have mapped out. Now I do indeed mean it of all the things just mentioned. For just as the common logic, which runs things by syllogism, reaches not only to the natural but also to all the other sciences; so mine, which advances by Induction, takes in everything [*Novum organum* I.127].

What this suggests is that Bacon thought of his method as a general tool, like the syllogism, that is applicable wherever scientific reasoning is needed.

But there is another side of Bacon. Recent studies of Bacon have emphasized his own natural philosophical commitments, and the underlying conception of nature that runs through his writings, including, for example, natural historical works like the *Sylva sylvarum* (1626) [Bacon, 1858–1874, vol. II, pp. 325–672]. In addition to its numerous observations and experiments, the *Sylva* contains much evidence for Bacon's substantive views about matter and the make-up of the world. One can find much similar material in the discussion of the so-called "prerogative instances" or "instances with special powers", as Graham Rees has translated them, that occupy the greater part of *Novum organum* II, a part that is often neglected by modern readers[2]. It is not surprising that these natural philosophical commitments are intertwined with the method and its statement in the *Novum organum*. In this short essay, I would like to argue that despite what we look for in a method – and what Bacon may have thought he had given us in the *Novum organum* – his method is deeply connected to aspects of his underlying view of nature: far from being a neutral and presuppositionless procedure for decoding all aspects the world, Baconian method is a tool for building a science of the physical world as he, Bacon, understood that world to be, helping us to fill out some of the details within the constraints of an apparently rigid and perhaps even a priori conception of the general outlines of the way the world is.

[2] On Bacon's matter theory and its role both in and out of the *Sylva sylvarum*, see [Rees, 1977; Rees, 1996; Giglioni, 2010]. On its role in the *Novum organum*, see Graham Rees's remarks in the introduction to that work in [Bacon, 1996–, pp. lxxvii–xcii], as well as his notes on the "instance with special powers" in [*Novum organum* II.21–51], which can be found in [Bacon, 1996–, pp. 550–586].

At this point I would like to turn to the method, as Bacon develops it in the opening aphorisms of *Novum organum* II. That text begins with an account of what Bacon thinks is the proper goal of inquiry into nature. He writes:

> The work and aim of human power is generate and superinduce a new nature or new natures on a given body. The work and aim of human knowledge is to discover… the form, or true difference, or *natura naturans*, or source from which a given nature arises [Bacon, *Novum organum* II.1].

The claim here is that what the investigator seeks to find is the "the form, or true difference, or *natura naturans*, or source from which a given nature arises". Bacon's idea here is that there are certain "natures" which are found in bodies. Associated with such natures are "forms", that from which a given nature arises. The primary goal of investigation is to find such forms. But there are secondary goals as well:

> And to these primary works two secondary and lesser ones are subordinated: to the former the transformation, within the bounds of the possible, of concrete bodies from one into another; to the latter the discovery, in every case of generation and motion, of the *latent process* carried on from manifest efficient cause and manifest material cause all the way to the form implanted, and likewise the discovery of the *latent schematism* of bodies at rest and not in motion [ibid.].

The first of these secondary works is the transformation of bodies of one sort into bodies of another sort, for example, the transformation of lead into gold. The second is the discovery of the way in which "concrete bodies as we find them in nature [arise] in nature in her ordinary course", that is the "*latent process*" by which they are formed [*Novum organum* II.5]. Similarly, the investigator also seeks to know the "latent schematism" (or, as it is sometimes translated, the "latent configuration") of bodies. By this Bacon seems to mean the make-up of its parts and their organization. Bacon compares this to alchemical analysis, "the separation of bodies by distillation and other modes of dissolution", though Bacon prefers "a separation and dissolution of bodies not by fire indeed but by reason and true Induction" [*Novum organum* II.7].

Some concrete examples will make clearer just what Bacon has in mind here. The main goal of inquiry, as we have seen, is the generation or superinduction of a nature on a body. This can be done by observing how, for example, the color or ductility of gold arises through the processes by which gold is produced in nature, by the *latent process*. But there is another, more direct way. We can consider

> …a body as an array or conjugation of simple natures; for instance, in gold these things come together: that which is yellow; that which is heavy up to such and such a weight; that which can be beaten or drawn out to such and such an extent; that which cannot become volatile, or lose mass

> by fire; that which can flow to such and such a degree; that which can be separated or dissolved by this or that means; and so on for the rest of the natures which come together in gold [*Novum organum* II.5].

On Bacon's view, there are a certain number of what he calls "*simple* natures", basic properties that combine with one another to form bodies of different sorts, as in the example of gold. These are what he calls the "primordia of nature and, indeed, the primary passions and desires of matter" in the *Distributio operis* of the *Instauratio magna*, published with the *Novum organum*. [Bacon, 1996–, vol. XI, pp. 38–39] And associated with each simple nature is a "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 [*Novum organum* II.4].

The form is that which determines the presence or absence of a (simple) nature. And if we know the forms of the simple natures that make up a body with a given nature, that is, with a given combination of simple natures, then we have, in principle at least, the means of transforming the body:

> For he who knows the forms and 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 [*Novum organum* II.5].

I should point out that this conception of body is a very significant commitment. The idea here is, first of all, that there are a certain number of privileged properties in bodies, the "simple natures". All bodies can be thought of as an aggregated of such simple natures, unified in a single thing which can be said to have all the properties conjointly. And secondly each of those properties has a single form which is present in each instantiation of the simple nature:

> The man who knows the cause of some nature (such as whiteness or heat) only in certain subjects has incomplete knowledge of it; and the man who can induce an effect only on certain materials… has, in the same way, incomplete power… But he who knows forms grasps the unity of nature beneath the surface of materials which are very unlike. Thus is he able to identify and bring about things that have never been done before, things of the kind which neither the vicissitudes of nature, nor hard experimenting, nor pure accident could ever have actualised, or human thought dreamed of. And thus from the discovery of forms flows true speculation and unrestricted operation [*Novum organum* II.3].

That is to say, if heat is a simple nature (as it seems to be for Bacon), then having that simple nature (that is, being hot) will be the instantiation

of a the *same* form in *every* body that is hot: there won't be a special kind of heat for water, another for fire, and another for chili pepper. And if we can induce that nature on a body – *any* body – then we can endow that body with the simple nature of heat. And if in a body we can induce all of the simple natures that pertain to gold, for example, we will have produced gold itself[3].

In the *Novum organum*, these preliminaries are followed by an outline of the method for interpreting nature, and an example. The interpretation of nature is a two-stage project for Bacon:

> Now the directions concerning the Interpretation of Nature comprise two general departments: the first is to do with extracting and fetching up axioms from experience, the second with deriving and drawing down new experiments from axioms [*Novum organum* II.10].

Bacon then focuses on the first of these projects, the derivation of axioms from experience. This, in turn, has three parts:

> Now the first is divided into three parts, i.e. into three ministrations: the ministration to sense, the ministration to memory, and the ministration to mind or reason [ibid.].

The first of these, the "ministration to sense", is the preparation of "a sound and sufficient natural and experimental history". The second, the "ministration to memory", is the arrangement of the natural historical inquiries into a form that they can be more easily used for drawing inferences:

> But *Natural and Experimental History* is so various and scattered that it may bewilder and distract the intellect unless it be set down and presented in suitable order. So we must fashion *Tables*, and *Structured Sets of instances*, marshalled in such a way that the intellect can get to work on them [*Novum organum* II.10].

And then, in the third part, the "ministration to mind or reason", the mind uses the tables to draw out the conclusion of axioms from the natural history so arranged.

Bacon works out an example of how exactly this is supposed to work through an investigation of the form of heat. The example begins with second part of the project, the "ministration to memory" or the formation of tables. Assuming that we have assembled a natural history, Bacon shows how it should be arranged into tables. He presents the results

[3] On simple natures and forms in Bacon, see, e.g., [Jardine, 1974, chapt. 5; Fattori, 1983; Urbach 1987, pp. 61–72; Pérez-Ramos, 1996]. These sources show that the doctrine is not found only in the *Novum organum*, but also in a significant number of other writings, including the *Valerius terminus,* the *Descriptio globus intellectualis*, the *De augmentis scientiarum*, the *Sylva sylvarum*, etc. Given my special interest in the discussion of method in the *Novum organum* in this essay, I will largely restrict myself to Bacon's account in that text.

of natural historical investigation into heat divided into three tables. The first is "Instances which share in the nature of heat" [*Novum organum* II.11]. This is a listing of things that are exhibit heat, that is things that are hot. The second is a table of "Instances in proximity which are deprived of the nature of heat" [*Novum organum* II.12]. This consists of things that lack heat, but are coordinated with things that are hot from the first table. So, for example, in the first table we find "the Sun's rays, especially in summer and at noon", and corresponding to this in the second list we find the rays of the Moon, stars and comets, which are not hot. (Not every thing in the first table has a corresponding entry in the second. "All flame" appears in the first table, but in the second table Bacon comments that "All flame is always more or less hot, and we can attach no Negative to it at all", though Bacon does note that the will-o'-the-wisp is not hot, and the flame of spirit of wine (alcohol) is "soft and gentle".) And finally the third table is the "Table of degrees or comparative table" [*Novum organum* II.13]. This is a table of things where heat comes in degrees. So, for example, "The Sun grows hotter the nearer it gets to the perpendicular or zenith…" [ibid.]

After these tables are constructed, we then use "mind or reason" to produce the first stage of the interpretation of nature. In the case of the form of heat, we are looking for what all of the instances of heat in the first table have in common, but is lacked by all of the "instances in proximity" that lack heat in the second table, and which varies greater or lesser as heat is found more or less in the various things found in the third table. This, Bacon argues, will give us the form of heat, or, at least, the preliminary statement of the form of heat, what Bacon calls "the *Provisional Interpretation*, or *First Vintage*" [*Novum organum* II.20]. This is the conclusion Bacon reaches:

> Each and every *Instance* indicates that the nature of which heat is a limitation is motion… From what I have said of this motion (namely that it is like a genus to heat's species), I do not mean that heat begets motion or that motion begets heat (though in some cases these things are true) but that the very heat itself or *Quid ipsum* of heat is motion and nothing else; but this conclusion is limited by *Differences* which I shall give in a moment… [*Novum organum* II.20; Bacon, 1996–, vol. XI, pp. 262–263]

The preliminary or provisional conclusion of the investigation, then, is that heat just *is* a kind of motion. But what kind of motion? Bacon continues:

> The *First Difference* then is this: that Heat is an expansive motion, by which a body strives towards self-dilatation, and takes up a greater sphere or dimension than it filled before…
> The *Second Difference* is a modification of the first, viz. that heat is an expansive motion towards the circumference, but yet with this rider: that the body is borne upwards at the same time…

> The *Third Difference* is this: that heat is a motion which is not uniformly expansive through the body as a whole but through its smaller particles, and at the same time is impeded, repelled, and beaten back, in such a way that the body takes on a juddering motion, forever shaking, straining, and struggling, and unsettled by constant rebounding…
> The Fourth Difference is a modification of the last, i.e. that the motion of provocation or penetration must be rather rapid and not at all dull, and proceed by way of particles which, though minute, are not the most subtle, but rather larger [*Novum organum* II.20; Bacon, 1996–, vol. XI, pp. 264–271].

Now, it isn't obvious how Bacon gets this conclusion from his tables. But I will set this interesting and important question aside to make a couple of broader observations[4].

First of all, as Bacon presents it in these aphorisms, the method for interpreting nature is very much connected with the goal of investigation, as Bacon articulates it in *Novum organum* II.1: "The work and aim of human power is generate and superinduce a new nature or new natures on a given body. The work and aim of human knowledge is to discover… the form, or true difference, or *natura naturans*, or source from which a given nature arises". And this aim is very closely connected with Bacon's particular notion of a nature, in particular, the idea of a *simple* nature and the idea that bodies can be thought of as conjunctions of natures. This view is a very significant assumption about the world, on a number of levels: that there is such an alphabet of sensible qualities that combine in different ways to produce all of the different kinds of bodies in the world, and that each of them has a unique form, something that is present whenever the nature is present and absent whenever it isn't, and that can be imposed on a body in order to instantiate the nature in a given body.

And secondly, the first vintage that Bacon arrives at at the end of this example, that heat is a specific kind of motion, shows another important assumption that Bacon brings to the method. Bacon's account of heat as motion in this example is quite often interpreted as an anticipation of the kinetic-molecular account of heat, which holds that heat is a function of the motion of the atoms, molecules, or corpuscles that make up a sensible body; the faster these insensible bodies are moving with respect to one another, the hotter the body as a whole is[5]. But this is not what Bacon had in mind.

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[4] Bacon's reasoning from the tables to the first vintage, see Graham Rees's comments in his introduction to the *Novum organum* [Bacon 1996-, vol. XI, pp. lxxii–lxxvii].

[5] Many commentators have credited Bacon with an anticipation of the kinetic-molecular theory of heat. See, e.g., [Urbach, 1987, p. 183; Pérez-Ramos, 1996, pp. 107–108; Gower, 1997, pp. 56–57; Snyder, 1999, pp. 536–537; Gaukroger, 2001, pp. 147–148; Henry, 2002, pp. 130–131]. McMullin also reads Bacon as having anticipated something like the kinetic-molecular theory of heat, but he sees that as problematic. Since he sees induction as coordinating observables with other observables, McMullin sees an inductive inference to an unobserved mechanism as problematic. See [McMullin, 1990, pp. 52–53].

In the kinetic-molecular account of heat, the kind of motion at issue is just local motion, change of place over time. But this is not the conception of motion at issue. Bacon contrasts local motion with what he considers the true physical kinds of motion. He writes:

> …if someone sees (for example) that bodies have an appetite for mutual contact, so that they do not let the unity of nature be completely broken up or torn apart to create a vacuum; or if someone says that bodies have an appetite for recovering their natural size or tension so that if squeezed within or stretched beyond it, they at once try to recover and take up their old sphere or bulk again… then these and others like them are truly physical kinds of motions; whereas those others [i.e. local motions] are simply logical and scholastic, as is obvious if you compare them [*Novum organum* I.66; Bacon, 1996–, vol. XI, pp. 106–107].

Later, in *Novum organum* II.48 Bacon gives a list of nineteen different kinds of motion. Take for example, what he calls the motion of liberty and the motion of matter:

> …in motion of liberty bodies shrink, run away from and spurn a new dimension, a new sphere or new dilatation or contraction (for this range of expressions refers to the same thing), and fight with all their might to spring back and regain their old consistency. But in motion of *Hyle* [i.e., matter], on the other hand, bodies long for a new sphere or dimension, and hanker after that willingly and without hesitation, and sometimes (as in gunpowder) with devastating force… [*Novum organum* II.48; Bacon, 1996–, vol. XI, pp. 388–389]

Local motion is certainly involved here, but these motions involve shrinking from, fleeing from, spurning, longing for, desiring, and in the earlier passage I quoted, appetite. Matter is considered in some sense animate, and motions constitute the basic appetites of matter. After his listing of motions in *Novum organum* II.48, Bacon writes:

> Thus then have I set out the species or simple elements of the motions, appetites and active virtues which are in nature most catholic. And in so doing I have outlined a fair portion of natural philosophy [ibid., pp. 412–413].

Indeed, shortly after the *Novum organum* was published, Bacon wrote a short *Abecedarium novum naturae* (1622), an apparent attempt at formulating an alphabet of basic notions for describing reality, which integrates a fair bit of what he says about motion in *Novum organum* II.48[6].

[6] [Bacon, 1996–, vol. XIII, pp. 172–225]. See especially pp. 190–215, where Bacon discusses motions, simple or compound. There is also a short account of the "appetites and motions" of body that relates closely to the account in the *Novum organum* II.48 in the *De augmentis scientiarum* (1623), bk. 3, chapt. 4, Bacon, 1858–1874, vol. I, pp. 560–561, translated in Bacon, 1858–1874, vol. IV, pp. 355–357. In the *De augmentis*,

This notion of motion is thus basic to the way in which Bacon thinks about the fundamental physics of bodies in this context. When he is looking for the form of the simple nature heat, it is in terms of motions that he frames it. And when he discusses imposing the simple nature heat on a body, it is given in terms not of local motion, but of imposing motions of this sort:

> If in any natural body you are able to excite a motion of self dilatation or expansion, and to repress the motion and turn it back on itself in such a way that the dilatation does not go forward smoothly but is now prevails and now forced to retreat, then without doubt you will generate heat: regardless of whether that body be elementary (as they have it) or impressed by the heavenly bodies, luminous or opaque, tenuous or dense, expanding locally or keeping to its original dimensions, tending to dissolution or staying in its original state, animal, vegetable or mineral, water, oil or air, or any other substance whatever that is susceptible to the motion just mentioned. [*Novum organum* II.20; Bacon, 1996–, vol. XI, p. 270–71]

Though Bacon doesn't say so explicitly, I think that it is reasonable to assume that the forms of at least some of the other simple natures would be expressed in similar terms[7].

It is important to notice the significant presuppositions that Bacon makes when setting out a method for interpreting nature. Whatever he may have claimed about his project for interpreting nature, Bacon's

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the account of appetites and motions is preceded by an account of the "configurations of matter", including dense, rare, heavy, light, hot, cold, etc. These seem to be what he calls the simple natures in other texts.

7 The *Abecedarium* includes concepts other than motions, and perhaps some of these other concepts would be involved in the forms of other simple natures. But it is difficult to say, since there is no extant text I know of that would settle the question. Bacon left an extensive natural history of two presumably simple natures, dense and rare, presumably written in the early or mid-1620s, of which two versions survive in ms.; see [Bacon, 1996–, vol. XIII, pp. 2–34 and 36–169]. But this is a natural historical investigation of weight and density, and in it Bacon doesn't say anything substantive about what the appropriate forms might look like. In the much earlier *Valerius terminus* (ca. 1603), Bacon does explore the conditions under which whiteness is produced in bodies; see [Bacon, 1858–1874, vol. III, pp. 235–237]. Though he doesn't use the vocabulary of natures and forms, he does talk about finding "somewhat which, if it be present, the effect you seek will of necessity follow" and "somewhat which if it be absent the effect you seek will of necessity withdraw" [ibid., pp. 235–236]. Bacon then considers various configurations of matter which will result in whiteness. But admitting that he has not yet found the necessary and sufficient conditions for whiteness, that is, what he will later call the form of whiteness, he stops the investigation: "to ascend further by scale I do forbear…" [ibid., 236]. So it is difficult to say what he thought the final form of whiteness would look like in this case. For a discussion of this case, relating it to the method of the *Novum organum*, see [Gaukroger, 2001, pp. 143–145].

method doesn't start with a blank slate: his is a method for investigating nature, not regarded as completely open and undetermined, but nature *as he understood it to be in a broad sense*. It presupposes that things in the world are made up of simple natures, each of which has a well-defined form. It assumes that a nature can be imposed on a body if we just impose the form of that nature. Furthermore, it presupposes the broad outlines of a fundamental natural philosophy, that is, his account of motion, the desires and appetites of body. The open question, which the method is supposed to answer through empirical investigation, is just what motions, desires, and appetites of body go into the form of a particular simple nature. Which is to say, Bacon's method is not neutral at all, but is deeply intertwined with non-trivial details of his natural philosophy.

What are we to make of this feature of Bacon's method? How are we to understand the apparent assumptions Bacon makes in setting out his method of interpreting nature? How can Bacon allow himself these substantive assumptions about nature in an enterprise that is supposed to tell us how we can discover how nature is through empirical investigation?

Some number of commentators have noted Bacon's assumption of the theory of simple natures and their forms, or the role that his account of the motions, that is the desires and appetites of bodies plays in the project, though they haven't noticed or confronted the deep question that this raises for his self-declared empirical method[8]. Others may have noticed the assumptions, but questioned their significance. Robert Leslie Ellis, for example, one of the editors of the great 19th Century edition of Bacon's works, noted the account of forms and simple natures, but then wrote:

> I am… much disposed to believe that the doctrine of Forms is in some sort an extraneous part of Bacon's system. His particular method may be stated independently of this doctrine… [Bacon, 1858–1874, vol. I, p. 28]

Various other commentators have recognized something of what I was arguing here, the dependence of Bacon's method in the *Novum organum* on substantive assumptions about nature. When discussing the exposition of the method and the example of heat in *Novum organum* II.1–20 in his introduction to the Oxford Francis Bacon volume containing that text, Graham Rees notes that "…Bacon has an agenda here, i.e. the promotion of a particular kind of theory-led research" [Bacon, 1996–, vol. XI, p. lxix]. However, so far as I can see, Rees never explains exactly what he means by this, and how it fits into Bacon's larger experimental program. Other commentators appeal to the fifth part of Bacon's *Instauratio magna*, the "Precursors, or Anticipations of the Philosophy to Come" [ibid., vol. IX, pp. 26–27] to understand the assumptions

[8] See, e.g., [Jardine, 1974, chapt. 5; Urbach, 1987, pp. 61–72; Malherbe, 1996, p. 89; Snyder, 1999, pp. 536–537; Gaukroger, 2001, pp. 138–153].

that Bacon is making here. Bacon characterizes these anticipations as follows:

> …[T]he fifth part is brought in only as a temporary measure pending completion of the rest… I make up the fifth part of the work from things which I myself have either discovered, proved or added, yet not by the proper process and prescriptions for interpreting… [T]hese things can serve as wayside inns in which the mind may find rest for a while as it presses onwards towards more certain conclusions. All the same I declare that I do not in the least wish to be held to these discoveries of mine, since they have not been found out or proved by the true form of interpretation [Bacon, 1996–, vol. IX, pp. 42–45].

William Lynch, if I understand him correctly, sees the appeal to a preliminary conception of body as an example of these anticipations[9]. While I find his exact suggestion somewhat unclear, Lynch seems to be suggesting that in order to be able to give convincing examples of the method in action, Bacon allows himself to appeal to some anticipations. But properly speaking, Lynch claims, these assumptions must be derived from experience by the method, if they are to enter Baconian science[10].

Bacon himself suggests that such assumptions could and should in principle be confirmed by experience. As I noted above, the account of motion in terms of which the simple nature of heat is interpreted in the *Novum organum* is very closely related to the subject matter of the *Abecedarium novum naturae*, a slightly later account of the basic vocabulary of nature. In the introductory paragraphs of that unpublished text, Bacon notes that "the *Abecedarium* belongs to Part Four of the *Instauration*, the part which is the ladder or machine of the intellect" [ibid., vol. XIII, pp. 172–173]. Now, part four of the *Instauratio magna*, the "ladder of the intellect", is intended "to set out examples of investigating and discovering according to my plan and way," that is, according to the method of the *Novum organum*; it is, as he says, "really nothing other than the application of the second part [of the *Instauratio magna*, that is, the *Novum organum*] in detail and at large" [ibid., vol. XI, pp. 42–43] But after relating the *Abecedarium* to the fourth part of his *Instauratio* project, Bacon continues:

> Yet this is not the ladder proper, rather it is as a preparative to it. Indeed, the supply of instances and experiments available to me is wholly insufficient for the actual ladder. However, in case I come in for the criticism that someone levelled against the priests in consequence of their fathers,

[9] Lynch doesn't actually say this explicitly, but in characterizing the assumptions that Bacon brings to his example of the method, he quotes from Bacon's discussion of the anticipations in the *Instauratio*. See [Lynch, 2001, p. 12].

[10] Ibid., pp. 9–12.

> I have judged it more useful to urge and advance the work in many things than to perfect it in a few [Bacon, 1996–, vol. XIII, pp. 172–173].

If the assumptions about nature Bacon sets out in the *Abecedarium* and in parallel passages in *Novum organum* II.48 are to be considered as examples of the method and legitimate parts of the "Ladder of the Intellect", then they must be derived from observation and experiment using the method. But Bacon himself never attempts to show how this might be done. Rather than an example of the method, Bacon calls them "a preparative to it", and demurs that at the time he was writing, he lacked the empirical basis on which to establish them properly. I suspect that in the end, even if he had the appropriate natural histories and tried to establish these preliminaries through the method, Bacon would have found the method unable to justify them in the way in which it purports to establish the forms of the simple natures: a method whose goal is to find the forms of simple natures in terms of the motions and appetites of matter cannot also be expected to establish that there are simple natures, and that simple natures have forms, and that those forms must be expressed in the particular way that Bacon thinks they must.

In the end it is difficult to figure out how to think about the assumptions Bacon brings to his method in the context of his apparent desire to base natural philosophy and the control of nature directly on observation and experiment. They are certainly not examples of the method, as noted earlier. Nor are they anticipations in Bacon's sense, nor are they *a priori*. Unlike the precursors or anticipations of the philosophy to come, which seem very tentative, Bacon seems genuinely committed to these doctrines. He is certainly committed enough to them to make them fundamental to the method that he presented. And I think that he believed that they will survive into any final account of the natural world. However, that is not enough to make them *a priori*: I would be very surprised if Bacon thought that like the *a priori* truths of arithmetic or geometry they couldn't be given up under appropriate circumstances. The assumptions Bacon thought necessary to get his method going don't fit neatly into the Baconian framework, and to understand them we have to think outside of his conceptual box.

Let me suggest a way of thinking about these assumptions. In this connection, I want to appeal to an interesting remark that Sir Karl Popper made about observation and experiment. Popper wrote:

> An observation is always preceded by a particular interest, a question, or a problem – in short, by something theoretical… Thus we can assert that every observation is preceded by a problem, a hypothesis (or whatever we may call it); at any rate by something that interests us, but something theoretical or speculative. This is why observations are always selective, and why they presuppose something like a principle of selection [Popper, 1972, pp. 342–343].

Popper, of course, has a larger program for scientific inquiry, falsificationism, a view in which science progresses by making bold conjectures and then trying to refute them, a view that is explicitly at odds with what he understands Baconian induction to be[11]. I certainly don't want to argue for that here (or anywhere else, for that matter). Nor, for that matter, do I want to advance a Popperian interpretation of Baconian method, which can be found in the literature[12]. But Popper's point about observation is interesting, and worth taking seriously. Nor is it evidently inconsistent with at least some things that Bacon says about his method. For example, consider the comparison mentioned above that Bacon made between his method and the ant, the spider, and the bee. Unlike ants, who simply gather things from nature but do nothing with them, or spiders, who "spin webs from their own entrails", Bacon's bee "takes the middle path: it collects its material from the flowers of the field and garden, but its special gift is to convert and digest it" [*Novum organum* I.95]. The bee does not gather just anything: it looks specifically for pollen. And the character of the honey will depend on the kind of pollen gathered, just as the conclusions of Bacon's method will depend on the details of the natural histories with which he starts. But just as Bacon's method will issue in a form of a simple nature, expressed in terms of the fundamental appetites and motions of matter, the bee's transformation of the pollen will result in honey, and not some other kind of product.

Popper's point is that the investigation of nature can only take place if we make assumptions about what we are looking for, and what we are going to do with it, and these will involve assumptions about the nature and the aims of inquiry. As the assumptions we bring to method, the aims of inquiry cannot be justified directly by the method itself: it is difficult to see how the method that Bacon outlines in the *Novum organum* could be used to establish empirically the doctrine of simple natures and forms, or the assumptions about the fundamental motions and appetites of matter.

How then should we think about these substantive assumptions that Bacon brings to the method in the *Novum organum*? I propose that they are what we might call *methodological anticipations*, or a *methodological a priori*. They can be thought of as "preparative" to the method insofar as assumptions of some sort are necessary to get the method off the ground. Perhaps this is what Bacon meant in the *Abecedarium* that the alphabet of nature he was proposing there is "preparative" to the ladder of the intellect. One can say, in the spirit of Bacon's project, if not according to the letter, that such assumptions can be said to be supported by experience to the extent that when those assumptions are brought to bear on the method, the resulting method is capable of leading us to an account of nature that allows us the sort of control of nature that Bacon

[11] The classic statement of this is [Popper, 1959].

[12] See [Urbach, 1982].

seeks. But this conjecture takes us beyond exegesis and into philosophy proper. In the end, I suspect that Bacon himself was probably as uncertain about how to think about these apparently necessary assumptions as his later commentators are[13].

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