Novum Organum

Nature's Hidden Processes and Structures (Novum Organum Book 2: 1-9)

This is the ninth post in the Novum Organum sequence. For context, see the sequence introduction. For the reading guide, see earlier posts in the sequence.

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Aphorism Concerning the Interpretation of Nature: Book 2: 1–9

by Francis Bacon

[[Bacon makes a distinction between *human power* vs *human knowledge* which may very roughly analogized as engineering vs science, i.e. being able to do things vs knowing things.]]

1. What **human power** does and is intended for is this:

- For a given body, to create and give to it a new nature (or new natures)—·e.g. melting gold or cooking chicken or dissolving salt in water·.

What **human knowledge** does and is intended for is this:

- For a given nature, to discover its form, or true specific differentia. . . .

·i.e. the features that a thing *must* have if it is to qualify as belonging to this or that natural kind, e.g. the features of *gold* that differentiate it from *metal* in general·. [Bacon adds two even more obscure technical terms, semi-apologising for them; they don't occur again in this work. Then:] Subordinate to these primary works are two secondary and less important ones. Under the 'power' heading: turning concrete bodies into something different, so far as this is possible—·e.g. turning lead into gold, if this can be done·. Under the 'knowledge' heading:

(i) in every case of generation and motion, discovering the *hidden* process through which the end-state form results from the *manifest* efficient ·cause· and the *manifest* material; and
(ii) discovering the hidden microstructure of bodies that are not changing.

·An example of **(i)**: the wax around the wick of a lighted candle melts. Flame is the efficient cause, wax is the material, and meltedness is the end-state form. But 'flame' and 'wax' stand for items that are *manifest*, obvious, out there on the surface; we know that when you apply one to the other you get melting; but that isn't knowing what *hidden* process is involved—what is *really basically going on* at the sub-microscopic level when flame melts wax·. ·An example of **(ii)**: discovering what the sub-microscopic structure is of wax when it isn't melting·.

2. Human knowledge is in a poor state these days—*how* poor can be seen from things that are commonly said. ·Not that they are *all* wrong·.

> True knowledge is knowledge by causes. Causes are of four kinds: material, formal, efficient, and final.

[A coin's •material cause is the metal, its •formal cause is the property of being round-with-a-head-inscribed-on-it etc., its immediate •efficient cause is the stamping of a die on the metal, and its •final cause is its purpose, use in commerce.]

So far, so good; but ·the concept of· *final cause* spoils the sciences rather than furthering them, except in contexts involving human action. The discovery of formal causes is despaired of. Efficient and material causes ·are real and solid and important,

but they· are investigated and believed in ·only as they appear on things' surfaces·, without reference to the hidden process through which the end-state form comes about; and, taken in *that* way, they are slight and superficial, and contribute little or nothing to true and active science. Earlier in this work [1-**51**] I noted as an error of the human mind the opinion that to understand what exists you have to look at forms. It's true that nature really contains only

> individual bodies, performing individual pure actions (*actus purus)* according to a fixed law;

[Bacon doesn't explain *actus purus*. In each of its other three occurrences he connects it with *laws*, and his meaning seems to be something like: 'the laws governing the pure actions of individual things, i.e. the things they do because of their own natures independently of interference from anything else'. If x does A partly because of influence from something else y, then x is not purely •active in respect of A because y's influence gives A a certain degree of •passivity. From here on, *actus purus* will be translated by 'pure action'.]

but in science this *law* is what we inquire into, discover, and explain; it is at the root of our theorizing as well as of our practical applications. When I speak ·approvingly· of 'forms', what I'm talking about is this law. . . .; I use the word 'form' because it has become familiar.

3. If someone knows the cause of a nature such as whiteness or heat in *only some* subjects, his •knowledge is incomplete; and if he can produce a certain effect in *only some* of the substances that are capable of it, his •power is incomplete. Now efficient and material causes

- are unstable causes, ·i.e. they can't be depended on to act in the same way in all cases·;
- they are nothing but *vehicles* ·in which the operative hidden structures and causes are carried·;
- they are causes that convey the ·end-state· form in *only some* cases.

If a man's knowledge is confined to *them*, he may arrive at new discoveries ·that hold generally about· some pre-selected class of fairly similar substances; but he doesn't get to the fixed, deeper boundaries of things—·'fixed' in contrast to the 'unstable' nature of manifest causes·. But someone who knows *forms* gets hold of the unity of nature in things that are ·superficially· most unalike, and this enables him to discover and bring to light really new things—things that no-one would ever have thought of, and that would never have come to light in the course of nature, or through deliberate experiments, or even by accident. So the discovery of forms leads to truth in theory-building and freedom in operation.

4. The roads to human power and to human knowledge lie extremely close together and are nearly the same. Still, because of the bad old habit of thinking in terms of abstractions, it is safer to get the sciences started and to carry them on from foundations that have to do with their *practical* part, and to let the practical part itself be a stamp of authenticity and also a limit-setter for the purely theoretical part. Well, then, let's think about a man who wants to confer some nature on a given body; he wants, for instance, to give a piece of silver the yellow colour that gold has or to make it heavier (subject to the laws of matter), or he wants to make an opaque stone transparent, or to make glass sticky, or to get something that isn't a plant to grow. Our question should be: what kind of rule or direction or guidance should he most wish

for? And we should answer this in the simplest and plainest terms ·that we can find·. **(1)** He will undoubtedly want to be shown something that won't let him down or fail when it is put to the test. **(2)** He will want a rule that won't tie him down to this or that particular means and mode of operation. Otherwise he may be stuck: he doesn't have the prescribed means, others are available and would do the job, but the rule he is to follow doesn't allow them. **(3)** He will want to be shown a procedure that isn't as difficult as the thing he wants to do—·e.g. he won't want to be told 'To make that silver yellow like gold, you must make it yellow like gold'·; he'll want something more practicable than that.

A true and complete rule of operation, then, will have to be a proposition that is **(1)** certain, **(2)** not constricting and **(3)** practicable. And the same holds for the discovery of a true form. For the form of a nature is such that:

- given the form, the nature is sure to follow; so that the form is absent whenever the nature is absent. . . .

and is also such that

- if the form is taken away, the nature is sure to vanish; so that the form is present whenever the nature is present. . . .

[Bacon ties each 'so that. . . ' clause to the wrong proposition—a mere slip, here corrected, rather than a logical error.]

Lastly,

- the true form derives the given nature from some essence that many other also things have and that is (as they say) b*etter known to nature* than the form ·we are discussing·.

[In calling something 'known to nature' Bacon means that it is a general law of nature; 'better known by nature' could mean 'a more general law of nature' or 'a generality that is more completely lawlike'.]

Here, then, is the procedure that I urge you to follow to get a true and perfect axiom of knowledge concerning a nature N_1: discover some other nature N_2 that is •convertible with N_1 and is •a special case of some more general nature N_3, falling under it as ·a true species falls· under a true and real genus. Now these two directions, the active ·rule of operation· and the contemplative ·rule of discovery·, are one and the same thing; what is most useful in operation is what is most true in knowledge.

5. There are two kinds of rule or axiom for the transformation of bodies. The first regards a body as a company or collection of simple natures. In gold, for example, the following properties meet:

- it is yellow in colour,
- it is heavy up to a certain weight,
- it is malleable and ductile up to a certain length,
- it doesn't vaporize or lose any of its substance through the action of fire,
- it turns into a liquid with a certain degree of fluidity;
- it is separated and dissolved by such-and-such means;

and so on for the other natures that come together in gold. This ·first· kind of axiom derives the thing from the forms of its simple natures. Someone who knows •the

forms of yellowness, weight, ductility, fixity, fluidity, dissolving and so on, and •the methods for giving them to bodies, and •their intensities and varieties, will work to have them come together in some body which will thereby be transformed into gold. This kind of operation pertains to the primary kind of action; ·the fact that it involves many natures doesn't mean that it is a later, non-basic kind of event·. For the principle of generating many simple natures is the same as that of generating just one; except that the investigator is more tightly constrained if more than one nature is involved, because of the difficulty of bringing together so many natures that don't easily combine except in the well-trodden ordinary paths of nature. Anyway, ·despite that drawback· it must be said that this mode of operation that looks to simple natures in a compound body starts from what in nature is constant and eternal and universal, ·namely *natures*·, and opens broad roads to human power—ones that in the present state of things human thought can scarcely take in.

The second kind of axiom depends on the discovery of hidden processes. It doesn't start off from simple natures, but from compound bodies just as they are found in the ordinary course of nature. For example, one might be inquiring into the origins of gold or some other metal or stone—How does it start forming? What process takes it from its basic rudiments or elements right through to the completed mineral? Or, similarly, the question of how plants are generated—What process takes the plant from the first congealing of sap in the ground, or from seeds, right through to the formed plant. . . .? Similarly ·we might inquire into· the process of development in the generation of animals from the beginning right through to birth; and similarly with other bodies.

This investigation concerns not only the •generation of bodies but also other motions and operations of nature. For example, we can inquire into •nutrition, the whole continuous series of events leading from the swallowing of the food through to its complete assimilation. Or into •voluntary motion in animals, from the first impression on the imagination and the continuous efforts of the spirits through to the flexing and moving of limbs. Or into •what is involved in the motion of the tongue and lips and other organs right through to the uttering of articulate sounds. Each of these inquiries relates to natures that have been concretized, i.e. brought together into a single structure; they concern what may be called particular and special practices of nature, not its basic and universal laws that constitute *forms*. ·That drawback of this approach is balanced by an advantage that it has over the other·. It has to be admitted that this second approach seems to have less baggage and to lie nearer at hand and to give more ground for hope than the first approach, ·i.e. the one described first in this aphorism·.

The practical-experimental approach corresponding to this ·second· theoretical approach starts from ordinary familiar natural events and moves on from them to ones that are very like them or at least not too unlike. But ·the merits of the first approach mustn't be forgotten·. Any deep and radical operations on nature depend entirely on the primary axioms, ·which are the business of the first approach·. And then there are the matters where we have no power to *operate* but only to *know*, for example the heavenly bodies (for we can't operate on them, alter them, or turn them into something else). With *these* things, whether we are investigating the facts about what happens in the heavens or trying to understand why it happens, we have to depend on the primary and universal axioms concerning simple natures, such as the nature of spontaneous rotation, of attraction or magnetism, and of many others that apply to more things than just to the heavenly bodies. 'Does the earth rotate daily, or do the heavens revolve around it?' Don't think you have a hope of answering this before you have understood the nature of spontaneous rotation.

6. The hidden process of which I speak is utterly different from anything that would occur to men in the present state of the human mind. For what I understand by it is not

- the different stages—different •s*teps*—that bodies can be •seen to go through in their development,

but rather

- a perfectly •continuous process which mostly •escapes the senses.

For instance: in all generation and transformation of bodies, we must inquire into

- what is lost and escapes, what remains, what is added;
- what is expanded, what is contracted;
- what is united, what is separated;
- what is continued, what is cut off;
- what pushes, what blocks;
- what predominates, what gives way;

and a variety of other particulars. And it's not just with the generation or transformation of bodies, but with all other alterations and motions we should inquire into

- what goes before, what comes after;
- what is quicker, what is slower;
- what produces motion, what ·merely· guides it;

and so on. In the present state of the sciences (in which stupidity is interwoven with clumsiness) no-one knows or does anything about any of these matters. For seeing that every natural action takes place

Latin: *per minima*

possibly meaning: by means of the smallest particles

or it might mean: by smallest steps, i.e. continuously

or at least by ones that are too small to strike the senses, no-one can hope to govern or change nature unless he understands and observes such action in the right way.

7. Similarly, the investigation and discovery of the hidden •microstructure in bodies is something new, as new as the discovery of the hidden •process and of the •form. At this time we are merely lingering in nature's outer courts, and we aren't preparing a way into its inner chambers. Yet no-one can give a body a new nature, or successfully and appropriately turn it into a new ·kind of· body without first getting a competent knowledge of the body so to be altered or transformed. Without that, he will run into methods that are worthless or at best cumbersome and wrongly ordered and unsuitable to the nature of the body he is working on. So that is clearly another road that must be opened up and fortified.

It's true that some good useful work has been done on the anatomy of organized bodies such as men and animals; it seems to have been done subtly and to have been a good search of nature. [The phrase 'organized bodies' refers to *organisms*; but the adjective 'organized' emphasizes the idea of a body with different parts *of different*

kinds, unlike such seemingly homogeneous bodies as lumps of lead.] But this kind of anatomizing lies within the visible range and is subject to the senses; also, it applies only to organized bodies. And it's obvious and easy compared with the true anatomizing of the hidden microstructure in bodies that are thought to be the same all through, ·i.e. homogeneous·; especially in things (and their parts) that have a specific character, such as iron and stone; and homogeneous parts of plants and animals, such as the root, the leaf, the flower, flesh, blood, bones and so on. But there has been *some* human industry even on this kind of thing; because this is just what men are aiming at when they break up homogeneous bodies by means of distillation and other kinds of analysis so as to reveal how the complex structure ·of the *seemingly* homogeneous compound· comes from combination of its various homogeneous parts. This is useful too, and is the kind of thing I am recommending; but in practice it often gives the wrong answer, because the procedures that are used—fire, heat, and so on—sometimes *create* new natures, which the scientist thinks existed in the compound before and were merely brought into the open by the separation procedure. Anyway, this is only a small part of the work of discovering the true microstructure of the compound body—a structure that is far more subtle and detailed ·than these processes could discover·. The operation of fire doesn't reveal and clarify this structure—it scrambles it.

So the way to separate and analyse bodies is not by fire but by reasoning and true induction, with experiments in a helping role; and by comparison with other bodies, and reduction to simple natures and their forms which meet and mix in the compound. In short, we must pass from Vulcan to Minerva—·from physical activities to intelligent mental ones·—if we want to bring to light the true •textures and •microstructures of bodies. It is on •these that depend all the hidden properties and powers of things, and all their so-called *specific* properties and powers. They are also the source of every effective alteration and transformation. For example, we must inquire what each body contains in the way of •spirit, and what of •tangible stuff; and regarding the spirit we should inquire into whether it is

- plentiful (making the body swollen) or meagre and scarce;
- fine or coarse,
- more like air than like fire, or vice versa,
- vigorous or sluggish,
- weak or strong,
- increasing or decreasing,
- broken up or continuous,
- agreeing or disagreeing with objects in the external environment,

and so on. Similarly, we must inquire into the tangible stuff (which is just as variable as spirit)—into its hairs, its fibres, its kinds of texture. Other things that fall within the scope of this inquiry are: •how the spirit is distributed through the bodily mass, with its pores, passages, veins and cells; and •the rudiments or first attempts at organic body. In these inquiries, and thus in all discoveries relating to hidden microstructure, the primary axioms cast a true and clear light which entirely dispels darkness and subtlety.

8. ·Three fears that you might have can be allayed·:

(1) This won't lead us to the doctrine of *atoms*, which presupposes •that there is a vacuum and •that matter doesn't change—which are both false. All we shall be led to are *real particles*—which ·are not merely hypothesized but· have been discovered.

(2) Don’t be afraid that all this will be so subtle—·so complex and fine-grained in its detail·—that it will become unintelligible. On the contrary, the nearer our inquiry gets to simple natures the more straightforward and transparent everything will become. The whole affair will be a matter of getting

- from the complicated to the simple,
- from the incommensurable to the commensurable,
- from the random to the calculable,
- from the infinite and vague to the finite and certain,

like the case of the letters of the alphabet and the notes of music. Inquiries into nature have the best result when they begin with physics and end in mathematics.

(3) Don’t be afraid of large numbers or tiny fractions. In dealing with numbers it is as easy to write or think *a thousand* or *a thousandth* as to write or think *one*.

9. From the two kinds of axioms that I have spoken of [**5**] arises a sound division of philosophy and the sciences. The investigation of forms, which are. . . .eternal and immutable, constitutes **Metaphysics**; the investigation of efficient causes, of matter, of hidden processes and of hidden microstructures—all of which concern the common and ordinary course of nature, not its eternal and fundamental laws—constitutes **Physics**. Each of these has a subordinate *practical* branch: physics has **mechanics**; and metaphysics has what in a cleaned-up sense of the word I call **magic**, on account of its sweeping ways and its greater command over nature. ‘Metaphysics’ etc. are the most accurate labels for these categories, but I am understanding them in senses that agree with my views.

The next post in the sequence will be posted Thursday, October 31 at latest by 4:00pm PT.

Tables of Presence, Nearby Absence, & Degrees of Intensity (Novum Organum Book 2: 10-14)

This is the tenth post in the Novum Organum sequence. For context, see the sequence introduction. For the reading guide, see earlier posts in the sequence.

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[[Bacon has begun demonstrating his scientific method in earnest. He uses the investigation of the nature of *heat* as his example. He explains that his approach works by compiling a *natural history*, i.e., data related to phenomena of interested which he arranges into three tables:

1) A table of *presence* which lists many examples where phenomena of interest in presence, e.g. many examples of things where we have heat. Bacon is quite thorough.

2) A table of *nearby essence*. To discriminate the true cause of heat, Bacon looks for examples of things that resemble those in the table of presence yet are lacking the heat. For the example, the light of the moon (cold) is contrasted with the light of the sun (hot) which is interesting given they are both heavenly bodies.

3) A table of *degrees* or *comparison* where are examples are brought where the amount of perceived heat differs in degree between things. This is also useful in discriminating the true underlying cause and and nature of heat.

Bacon is thorough in his examples here, listing an extreme variety of things. To his credit, he eventually hits upon that heat is about motion.

One the hand, these passages can be see as boring, but I see them as quite fascinating– it's remarkable to see how on the earlier pioneers of modern science thought and approached solving what to him was a great mystery. He did not rush, he did not get bored, instead he painstakingly collected his data. A superb demonstration of empiricism.]]

Aphorism Concerning the Interpretation of Nature: Book 2: 10-14

10. Having looked at *doctrines*, we must go on to *precepts*, dealing with them in the most direct way and not getting things the wrong way around. Guides for the interpretation of nature are of two fundamental kinds: **(1)** how to draw or fetch up axioms from experience; **(2)** how to get from axioms to new experiments. Precepts of kind **(1)** divide into three kinds of service: (i) catering to the senses, (ii) catering to the memory, and (iii) catering to the mind or reason. (i) First of all we must prepare an adequate and sound natural and experimental history, this being the basis for everything, for we are not to •imagine or •suppose but to •discover what nature makes or does. [Bacon doesn't return to (ii) memory.] (iii) But natural and experimental history is so various and diffuse that it confuses and scatters the intellect unless it is kept short and set out in a suitable order. So we must create tables and arrangements of instances that are done in such a way that the intellect can act on them. And even when this is done, the unaided and unguided intellect hasn't the competence to form axioms. Therefore in the third place we must use induction, true and legitimate induction, which is the very key of interpretation. But I must deal first with this ·induction·, though it comes last, and then I shall go back to the others.

[In fact, all the rest of the work has to do with what Bacon calls 'induction'.]

11. The investigation of forms proceeds in this way: For a given nature, we must first turn our minds to all known instances that agree in having this nature (they'll differ greatly in other ways). This collection is to be made in the manner of a ·natural· history, with no rush to theorize about it and with no great amount of subtlety. If for example we are to investigate the form of heat, we need a **table of instances of heat**. This is my **First Table**:

1. The rays of the sun, especially in summer and at noon.

2. The sun's rays reflected and condensed. . . .especially in burning glasses and mirrors.

3. Fiery meteors.

4. Lightning.

5. Eruptions of flame from the cavities of mountains.

6. All flame.

7. Burning solids.

8. Natural warm baths.

9. Hot or boiling liquids.

10. Hot vapours and fumes, and even air that becomes furiously hot if it is confined, as in reverbatory furnaces.

11. Weather that is clear and bright just because of the constitution of the air, without reference to the time of year.

12. Air that is confined and underground in some caverns, especially in winter.

13. All shaggy substances—wool, skins of animals, down of birds—have some warmth.

14. All bodies, whether solid or liquid, dense or rare (as air is), held for a time near a fire.

15. Sparks from flint and steel that are struck hard.

16. All bodies—stone, wood, cloth, etc.—when rubbed strongly (axles of wheels sometimes catch fire; and rubbing was how they kindled fire in the West Indies).

17. Green and moist plants jammed together, as roses or peas in baskets (hay in a damp haystack often catches fire).

18. Quicklime sprinkled with water.

19. Iron when first dissolved in *aqua fortis* [= nitric acid] in a test tube without being put near a fire (the same with tin, though not with the same intensity).

20. Animals, especially their insides (and *always* their insides), though we don't feel the heat in insects because they are so small.

21. Freshly dropped horse dung and other animal excrements.

22. Strong oil of sulphur and of vitriol has the effect of heat when it scorches linen.

23. Oil of marjoram and similar oils have the effect of heat in burning the bones of the teeth.

24. Strong alcohol acts as though it were hot: it makes egg-white congeal and turn white, as though it were cooked; it makes bread crusty, like toast.

25. Aromatic and hot herbs. . . .although not warm to the hand. . . .feel hot to the palate when they are chewed.

26. When strong vinegar or any acid is applied to parts of the body that don't have skin—the eye, the tongue, or on any part that has been damaged and lost some skin—it produces a pain like the pain heat produces.

27. Even keen and intense cold produces a kind of sensation of burning. . . .

28. Other instances.

I call this the Table of **Essence and Presence**.

12. Secondly, we must turn our minds to instances where the given nature is lacking, because—as I said above—the form should not only be present when the given nature is present but also be absent when the nature is absent. But a list of these would be endless! So the negatives should be linked with the affirmatives: we shall look into the

absence of the given nature only in things that are most like ones where the nature is present and apparent. I call this, which is my **Second Table**, the Table of **Divergence** or of **Nearby Absence**. These are instances where the nature of heat is absent but which are in other ways close to ones where it is present.

[Each tag of the form **#n** means that the topic is negative instances that are nearby to positive instance n.]

1. (**#1**) The rays of the moon and of stars and comets are not found to be hot to the touch; indeed the severest colds are experienced at the full moons. The larger fixed stars, however, when passed or approached by the sun, are thought to increase and intensify the heat of the sun. . . .

2. (**#2**) The rays of the sun in the so-called 'middle region' of the air don't give heat. (The usual explanation for this is pretty good: namely, that region is far enough away from the body of the sun that gives off the rays and from the earth that reflects them.) And this appears from the fact that on mountain-tops there is perpetual snow, unless they are very high: it has been observed that on the Peak of Tenerife and among the Andes of Peru the summits of the mountains are free from snow though there is snow a little way below the summits. Actually, the air at the very top is not found to be at all cold, but only thin and sharp—so much so that in the Andes it pricks and hurts the eyes by its excessive sharpness and also irritates the entrance to the stomach, producing vomiting. The ancients observed that on the summit of Olympus the air was so thin that those who climbed it had to carry sponges with them dipped in vinegar and water, and to apply them from time to time to the mouth and nose, because the air was too thin to support respiration. They also reported that on this summit the air was so serene, and so free from rain and snow and wind, that words written by the finger in the ashes of a sacrifice were still there, undisturbed, a year later. . . .

3. (**#2**) The reflection of the sun's rays in regions near the polar circles is found to be very weak and ineffective in producing heat: the Dutch who wintered in Nova Zembla and expected their ship to be freed by the beginning of July from the mass of ice that hemmed it in were disappointed in their hopes and forced to take to their row-boats. It seems, then, that the direct rays don't have much power, even down at sea level; and don't reflect much either, except when they are many of them combined. That is what happens when the sun moves high in the sky, for then the incident rays meet the earth at acuter angles, so that the lines of the rays are nearer each other; whereas when the sun ·is lower in the sky and so· shines very obliquely, the angles are very obtuse which means that the lines of rays are further from one another. Meanwhile, bear in mind that the sun may do many things, *including ones that involve the nature of heat*, that don't register on our sense of touch—things that *we* won't experience as detectable warmth but that have the effect of heat on some other bodies.

4. (**#2**) Try the following experiment. Take a glass made in the opposite manner to an ordinary burning glass, let the sun shine through it onto your hand, and observe whether it •lessens the heat of the sun as a burning glass •increases and intensifies it. It's quite clear what happens with *optical* rays ·shone through a glass·: according as the middle of the glass is thicker or thinner than the sides, the objects seen through it appear more spread or more contracted. Well, see whether the same holds for *heat*.

5. (**#2**) Try to find out whether by means of the strongest and best built burning glasses the rays of the *moon* can be caught and collected in such a way as to produce *some* warmth, however little. In case the warmth produced is too weak to be detected by the sense of touch, use one of those glasses that indicate the state of the

atmosphere in respect to heat and cold: let the moon's rays fall through the ·extra-powerful· burning glass onto the top of a glass of this kind, and then see whether the water sinks because of warmth.

[The 'glasses' in question are thermometers; see item 38 for Bacon's instructions on how to make and use one.]

6. (**#2**) Try a burning glass with a source of heat that doesn't emit rays or light—such as iron or stone that has been heated but not ignited, or boiling water, or the like. Observe whether the burning glass produces an increase of the heat as it does with the sun's rays.

7. (**#2**) Try a burning glass also with ordinary flame.

8. (**#3**) Comets (if we are to count these as meteors) aren't found to exert a constant and detectable effect in increasing the heat of the season, though they have been seen often to be followed by droughts. Moreover bright beams and pillars and openings in the heavens appear oftener in winter than in summertime, especially during the intensest cold but always accompanied by dry weather. (**#4**) Lightning-flashes and thunderclaps seldom occur in the winter, but rather at times of great heat. So-called 'falling stars' are commonly thought to consist of some thick and highly incandescent liquid rather than to be of any strong fiery nature. But this should be further looked into.

9. (**#4**) Certain flashes give light but don't burn; and these always come without thunder.

10. (**#5**) Discharges and eruptions of flame occur just as frequently in cold as in warm countries, e.g. in Iceland and Greenland. In cold countries, too, many of the trees—e.g. fir, pine and others—are more inflammable, more full of pitch and resin, than the trees in warm countries. This is an affirmative instance ·of heat·; I can't associate it with a ·nearby· negative instance because not enough careful work has been done on the locations and soil-conditions in which eruptions of this kind usually occur.

11. (**#6**) *All* flame, always, is more or less warm; there are no ·nearby· negative instances to be cited here. [Bacon then cites seven kinds of situation in which there are something like flames but little if any detected heat. He says, for example, that a sweaty horse when seen at night is faintly luminous. Then:]

12. (**#7**) *Every* body that is subjected to heat that turns it to a fiery red is itself hot, even if there are no flames; there are no ·nearby· negative instances to go with this affirmative. . . .

13. (**#8**) Not enough work has been done on the locations and soil-conditions in which warm baths usually arise; so no ·nearby· negative instance is cited.

14. (**#9**) To boiling liquids I attach the negative instance of *liquid in its own nature*. We don't find any tangible liquid that is warm in its own nature and remains so constantly; the warmth always comes from something outside the liquid and is possessed by the liquid only temporarily. The water in natural warm baths ·is not inherently warm; when it· is taken from its spring and put into a container, it cools down just like water that has been heated on a fire. The liquids whose power and way of acting makes them the hottest and that eventually *burn*—e.g. alcohol, chemical oil of spices, oil of vitriol and of sulphur, and the like—are at first cold to the touch; though oily substances are less

cold to the touch than watery ones, oil being less cold than water, as silk ·is less cold· than linen. But this belongs to the Table of Degrees of Cold.

15. (**#10**) Similarly, to hot vapour I attach the negative instance of the nature of vapour itself as we experience it. For although the vapours given off by oily substances are easily flammable, they aren't found to be warm unless they have only recently been given off by a body that is warm.

16. (**#10**) Similarly, to hot air I attach the negative instance of the nature of air itself. For in our regions we don't find any air that is warm, unless it has either been confined or subjected to friction or obviously warmed by the sun, fire, or some other warm substance.

17. (**#11**) I here attach the negative instance of weather that is *colder* than is suitable for the season of the year, which in our regions occurs during east and north winds; just as we have weather of the opposite kind with the south and west winds. . . .

18. (**#12**) Here I attach the negative instance of air confined in caverns *during the summer*. But *air in confinement* is something that needs to be looked into more carefully ·than has so far been done·. For one thing, it isn't certain what is the nature of air in itself in relation to heat and cold. It's clear that air gets warmth from the influence of the heavenly bodies, and cold perhaps from the exhalations of the earth and in the so-called 'middle region' of air from cold vapours and snow. So that we can't form an opinion about the nature of air by examining the open air that is all around us; but we might do better by examining it when confined. But the air will have to be confined in something that won't communicate warmth or cold to the air from itself, and won't easily let the outer atmosphere affect the confined air. So do an experiment using an earthenware jar wrapped in many layers of leather to protect it from the outer air; let the vessel remain tightly closed for three or four days; then open it and test the level of heat or cold either by touch or by a thermometer.

19. (**#13**) There's also a question as to whether the warmth in wool, skins, feathers and the like comes from •a faint degree of heat that they have because they came from animals, or from •some kind of fat or oil that has a nature like warmth; or simply (as I suggested in the preceding paragraph) from •the air's being confined and segregated. For all air that is cut off from the outer air seems to have some warmth. So: try an experiment with fibres made of linen, not of such animal products as wool, feathers or silk. It is also worth noting that when something is ground to a powder, the powder (which obviously has air enclosed in it) is less cold than the intact substance from which it was made; and in the same way I think that all froth (which contains air) is less cold than the liquid it comes from.

20. (**#14**) I don't attach any negative to this because everything around us, whether solid or gaseous, gets warm when put near fire. They differ in this way, though: some substances (such as air, oil and water) warm up more quickly than others (such as stone and metal). But this belongs to the Table of Degrees.

21. (**#15**) I don't attach any negative to this either, except that it should be noted that •sparks are produced from flint and iron and the like only when tiny particles are struck off from the substance of the stone or metal; that •you can't get sparks by whirling something through the air, as is commonly supposed; and that •the sparks themselves, owing to the weight of the body from which they are struck, tend downwards rather than upwards, and when they are extinguished they become a tangible sooty substance.

22. (**#16**) I don't think there is any negative to attach to this instance. For every solid body in our environment clearly becomes warmer when it is rubbed; so that the ancients thought (dreamed!) that the heavenly bodies' only way of gaining heat was by their rubbing against the air as they spun. On this subject we must look into whether bodies discharged from ·military· engines, such as cannon-balls, don't acquire some heat just from the blast, so as to be found somewhat warm when they fall. But moving air chills rather than warms, as appears from wind, bellows, and blowing with the lips close together. It isn't surprising that this sort of motion doesn't generate heat: it isn't rapid enough, and it involves a mass moving ·all together· rather than particles ·moving in relation to one another·.

23. (**#17**) This should be looked into more thoroughly. It seems that green and moist grass and plants have some heat hidden in them, but it is so slight that it isn't detectable by touch in any individual ·carrot or cabbage·. But then a lot of them are collected and shut up together, their gases aren't sent out into the atmosphere but can interact with one another, producing palpable heat and sometimes flame.

24. (**#18**) This too needs to looked into more thoroughly. For quicklime sprinkled with water seems to become hot either •by the concentration of heat that was previously scattered (as in the (23) case of confined plants) or •because the fiery gas is excited and roughed up by the water so that a struggle and conflict is stirred up between them. Which of these two is the real cause will appear more readily if oil is poured on ·the quicklime· instead of water; for oil will concentrate the enclosed gases just as well as water does, but it won't irritate it in the same way. We should also broaden the experiment •by employing the ashes and cinders of bodies other than quicklime, and dousing them with liquids other than water.

25. (**#19**) The negative that I attach to this instance is: other metals, ones that are softer and more fusible. When gold leaf is dissolved in *aqua regia* it gives no heat to the touch; nor does lead dissolved in nitric acid; nor again does *mercury* (as I remember), though *silver* does, and copper too (as I remember); tin still more obviously; and most of all iron and steel, which not only arouse a strong heat when they dissolve but also a vigorous bubbling. So it seems that the heat is produced by conflict: the *aqua fortis* penetrates the substance, digging into it and tearing it apart, and the substance resists. With substances that yield more easily hardly any heat is aroused.

26. (**#20**) I have no negative instances to attach to the heat of animals, except for insects (as I have remarked) because of their small size. Fish are found to have *less* heat than land animals do, but not a complete absence of heat. Plants have no heat that can be felt by touch, either in their sap or in their pith when freshly opened up. The heat in an animal varies from one part of it to another (there are different degrees of heat around the heart, in the brain, and on the skin) and also from one event to another—e.g. ·the animal's heat increases· when it engages in strenuous movements or has a fever.

27. (**#21**) It's hard to attach a negative to this instance. Indeed animal dung obviously has potential heat ·even· when no longer fresh; this can be seen from how it enriches the soil.

28. (**#22** and **#23**) Liquids, whether waters or oils, that are intensely caustic act as though they were hot when they break into bodies and, after a while, burn them; but they don't feel hot at first. But how they operate depends on what they are operating

on. . . . Thus, *aqua regia* dissolves gold but not silver; nitric acid dissolves silver but not gold; neither dissolves glass, and so on with others.

29. (**#24**) Try alcohol on wood, and also on butter, wax and pitch; and observe whether it has enough heat to melt any of them. For **24** shows it exhibiting a power that resembles heat in making bread crusty. Also, find out what it can do in the way of liquefying substances. Experiment with a thermometer or calendar glass, hollow at the top; pour some well-distilled alcohol into the hollow; cover it so that the spirit keeps its heat better; and observe whether by its heat it makes the water go down. [A 'calendar glass' is a thermometer. See item 38].

30. (**#25**) Spices and sharp-tasting herbs are hot to the palate and much hotter to the stomach. So we should see on what other substances they act as though they were hot. (Sailors report that when large quantities of spices are kept shut up tightly for a long time and then suddenly opened, those who first disturb and take them out are at risk of fever and inflammation.) Something else that can be tested: whether such spices and herbs in a powdered form will dry bacon and meat hung over them, as smoke does.

31. (**#26**) Cold things such as vinegar and oil of vitriol are corrosive and penetrating, just as are hot things such as oil of marjoram and the like. Both alike cause pain in living things, and tear apart and consume things that are inanimate. There is no negative to attach to this ·positive· instance. A further point: whenever an animal feels pain it has a certain sensation of heat.

[A warning about 'inanimate': it translates *non animatus*, which strictly means 'not breathing', and Bacon often uses it to cover plants as well as things that are 'inanimate' in our sense. This version will stay with 'inanimate' except in one place where 'non-animal' is required.]

32. (**#27**) In many contexts heat and cold have the same effect, though for different reasons. Boys find that after a while snow seems to burn their hands; cold preserves meat from going rotten just as fire does; and heat makes bodies shrink, which cold does also. But these and similar instances are better dealt with in the investigation of cold.

13. ·We have dealt with firstly (**11**) a Table of Essence and Presence, secondly (**12**) a Table of Divergence or of Nearby Absence. Now·, thirdly, we must turn our minds to instances in which the nature being investigated is found in different degrees, greater or lesser; either by comparing the amounts of it that a single thing has at different times or by comparing the amounts of it that different things have. The •form of a thing is the very •thing itself; the only difference between the thing and the form is just that between

the thing and the form

is just that between

the apparent and the real,
the external and the internal, or
the thing in reference to man and the thing in reference to the universe.

From this is rigorously follows that no •nature should be accepted as the true •form unless it—·i.e. the thing whose nature is in question·—always decreases when the

nature decreases, and increases when the nature increases. So I call this—my **Third Table**—the Table of **Degrees** or the Table of **Comparison**.

Here is my Table of **Degrees** or of **Comparison,** in relation to **Heat**. I start with substances that contain no degree of heat that can be felt by touch but seem to have a certain potential heat—a disposition and readiness to be hot. Then I shall move on to substances that are actually hot—hot to the touch—and to their intensities and degrees.

1. We don't encounter any solid, tangible things that just *are hot* in their own natures. No stone, metal, sulphur, fossil, wood, water or animal carcass is found to be hot. The water in ·naturally· hot baths seems to be heated by external causes—either by flames or subterraneous hot material such as is thrown up from Etna and many other mountains, or by bodies colliding as when iron or tin is ground to powder and heat is caused. Thus, there is no heat detectable by touch in non-living substances; though they differ in how cold they are—wood isn't as cold as metal. But that belongs to the Table of Degrees of Coldness.

2. However, many inanimate substances—such as sulphur, naphtha and oil extracted from rocks—have a lot of potential heat and are strongly disposed to burst into flame.

3. ·Some· substances that have been hot continue to have some of their former heat lurking in them. Examples of this are horse dung retaining the heat of the horse, also lime (and perhaps also ashes and soot) retaining the heat of the fire. . . .

4. As for the vegetable kingdom: no plant or part of a plant (such as sap or pith) is warm to the human touch. But as I have already remarked, green plants become warm when they are shut up; and some plants are warm and others cold, this being detectable by the *internal touch* ·as I call it· of the palate or stomach, and even to touch by external parts of the body ·such as the hands·. It takes a little time for this to develop; we see it at work in poultices and ointments.

5. We don't find anything warm to the touch in the parts of animals that have died, or in parts that they have excreted. Not even horse dung retains its heat unless it is enclosed and buried. Yet all dung seems to have potential heat, as is seen in how it enriches the fields. Similarly, the carcasses of animals have some such hidden potential heat. A result of this is that in cemeteries where burials take place daily the earth collects a certain hidden heat which consumes a newly buried body much faster than pure earth would. . . .

6. Substances that enrich the soil, such as dung of all kinds, chalk, sea sand, salt and the like, have some disposition to become hot.

7. When anything rots, there are the beginnings of slight heat, but not enough to be detectable by touch. Even the substances which when they putrefy break up into little animals (meat, cheese, etc.) don't feel warm to the touch; nor does rotten wood, which shines in the dark, feel warm to the touch. In rotting substances, though, heat sometimes announces itself by strong nasty smells.

8. The lowest degree of heat among things that feel warm to the touch seems to be the heat of animals, which varies over quite a wide range. At the bottom of the scale, as in insects, the heat is hardly perceptible to the touch; and the highest scarcely equals the heat the sun gives off in the hottest countries and seasons, and isn't too great to be tolerated by the hand. But it is said of Constantius, and of some others

who had a very dry constitution and bodily condition, that in acute fevers they became so hot as to burn slightly any hand that touched them.

9. Animals increase in heat by motion and exercise, wine and eating, sex, burning fevers, and pain.

10. When attacked by intermittent fevers, animals are at first seized with cold and shivering, but soon after they become exceedingly hot; and in burning and pestilential fevers they are very hot right from the start.

11. We should investigate the different degrees of heat indifferent ·broad kinds of· animals, such as fish, quadrupeds, snakes, birds; and also according to their ·narrower· species, such as lion, vulture, man. ·This would be, among other things, a check on popular beliefs·. For fish are generally thought to be the coldest internally, and birds—especially doves, hawks and sparrows—to be very hot.

12. We should also investigate the different degrees of heat in the different parts of the same animal. For milk, blood, semen and ova are found to be only mildly warm—cooler than the outer flesh of the animal when it is moving or agitated—but no-one has yet investigated what the temperature is in the brain, stomach, heart, etc.

13. In winter and cold weather all animals are cold externally, but internally they are thought to be even warmer ·than at other times·.

14. Even in the hottest countries and at the hottest times of the year and day, the heavenly bodies don't give off enough heat to kindle a flame in the driest wood or straw or even cloth, except when the heat is increased by burning glasses. But it can raise steam from moist matter.

15. Astronomers have a traditional belief that some stars are hotter than others. Of the planets, Mars is regarded as the hottest after the sun; then comes Jupiter, and then Venus. The moon is said to be cold and Saturn the coldest of all. Of fixed stars, Sirius is said to be the hottest, then Cor Leonis (or Regulus), then the Dog-star, and so on.

16. The sun gives off more heat the nearer it comes to the perpendicular [= 'to being straight overhead']; and this is probably true of the other planets also, within their own ranges of temperature. Jupiter, for instance, feels warmer when it is under Cancer or Leo than when it is under Capricorn or

17. The sun and the other planets can be expected to give more heat when they are closest to the earth than when they are furthest away. If it should happen that in some region the sun is at its closest and also near the perpendicular, it would have to give off more heat *there* than in a region where it is also at its closest but is shining more obliquely. So there should be a study of ·the heat-effects of· the planets in different regions according to how high or low in the sky they are.

18. The sun and other planets are thought to give more heat when nearer to the larger fixed stars. When the sun is in ·the constellation· Leo it is nearer to ·the stars· Cor Leonis, Cauda Leonis, Spica Virginis, Sirius and the Dog-star than when it is in ·the constellation· Cancer, though in the latter position it is nearer to the perpendicular ·and thus has one factor making for less heat and another making for more·. And we have to think that the parts of the sky that are furnished with the most stars, especially big ones, give off the greatest heat, though it isn't all perceptible to the touch.

19. Summing up: the heat given off by the heavenly bodies is increased in three ways —•by perpendicularity, •by nearness to the earth, and •by the company of stars.

20. The heat of animals, and the heat that reaches us from the heavenly bodies, are *much* less than

- the heat of a flame (even a gentle one) ,
- the heat from a burning body, and
- the heat of liquids and the air itself when strongly highly heated by fire.

For the flame of alcohol, even when scattered and not concentrated, is still enough to set paper, straw, or linen on fire. The heat of animals will never do that, nor will the sun without a burning-glass.

21. The heat of flames and burning bodies comes in many different intensities; but they haven't been carefully studied, so I can only skim across the surface of this topic. It seems that the flame of alcohol is the gentlest of all (unless perhaps the will-o'-the-wisp or the flames or sparks from the sweat of animals are even gentler). Next, I think, comes the flame from vegetable matter that is light and porous, such as straw, reeds, and dried leaves—and the flame from hairs or feathers is pretty much the same. Next perhaps comes flame from wood, especially wood containing little resin or tar. ·There is a distinction to be made within the class of flames from that kind of wood·: the flame from small bits of wood such as are commonly tied up in bundles is milder than the flame from trunks and roots of trees. Anyone can see this in the fact that a fire fuelled by bundles of twigs and tree-branches is useless in a furnace for smelting iron. After this, I think, comes flame from oil, tallow, wax and similar fatty and oily substances that aren't very caustic or corrosive. But the strongest heat comes from tar and resin, and even more from sulphur, camphor, naphtha, rock oil, and salts (after the crude matter is discharged), and from their compounds such as gunpowder, Greek fire (commonly called 'wildfire') and its variants, whose heat is so stubborn that it's hard to extinguish with water.

22. I think that the flame resulting from some imperfect metals is very strong and piercing; but all these things need to be looked into further.

23. The flame of powerful lightning seems to be stronger than any of those others, for it has been known to melt wrought iron into drops, which *they* can't do.

24. In burning bodies too there are different degrees of heat, but these haven't been carefully investigated either. The weakest heat of all, I think, is what comes from the sort of burning linen wick that we use to start fires with, and from the fuses that are used in firing cannons. After this comes burning charcoal made from wood or coal. . . .

[In what follows, a single Latin word is rendered sometimes as 'red-hot' and sometimes as 'burning', according to the context.]

But I think that red-hot metals—iron, copper etc.—are the hottest of all hot substances. But this needs to be looked into.

25. Some red-hot bodies are found to be much hotter than some flames. Red-hot iron, for instance, is much hotter and more destructive than flame of alcohol.

26. Of substances that aren't burning but only heated by fire, such as boiling water and air confined in reverbatory furnaces, some are found to be hotter than many flames and burning substances.

27. Motion increases heat, as you can see in bellows and by blowing ·hard into your hand·; so that the way to get a quiet fire to melt one of the harder metals is to take a bellows to it.

28. Try the following experiment with a burning-glass(I am describing it from memory). **(1)** Place a burning-glass nine inches away from a combustible body. **(2)** Place the burning-glass at half that distance from the object and then slowly move it back to a distance of nine inches. You will find that the glass doesn't burn or consume as much of the object in case **(1)** as it does in case **(2)**. Yet the cone and the focus of the rays are the same in each; it's the motion that makes the heat more effective.

29. [Omitted. What Bacon wrote doesn't make physical sense.]

30. Things don't burst into flames unless the flames have some empty space in which to move and play; except for the explosive flame of gunpowder and the like, where the fire's fury is increased by its being compressed and imprisoned.

31. An anvil gets very hot under the hammer; so if an anvil were made of a thin plate and were hit with many strong blows from a hammer I would expect it to it become red-hot. This should be tried.

32. If a burning substance is porous, so that the fire in it has room to move, the fire is immediately extinguished if its motion is checked by strong compression. For example, you can immediately extinguish the burning wick of a candle or lamp by snuffing it out with an extinguisher, or burning charcoal or coal by grinding it down with your foot.

33. The closer something is to a hot body the more heat it gets from it; and this applies to light as well—the nearer an object is to a light-source the more visible it becomes.

34. Combining different heats increases the ·over-all· heat unless the combining is done by mixing the hot substances together. For a large fire and a small fire in the same house give more heat than either alone, but warm water poured into boiling water cools it.

35. The longer a hot body is applied to something else,the more heat it gives it; because heat is perpetually being transferred and mixed in with the heat that is already there, so that amount of heat transferred increases through time. A fire doesn't warm a room as well in half an hour as it does if continued through a whole hour. Not so with light: a lamp or candle gives no more light after it has been long lighted than it did at first.

36. Irritation by surrounding cold increases heat, as you can see in fires during a sharp frost. I think this is not so much because the cold confines and contracts the heat. . . .as because it irritates it. ·Another example of such irritation—one that doesn't concern heat—occurs· when air is forcefully compressed or a stick is forcefully bent; it doesn't merely rebound back to its initial position but goes further than that. A careful experiment is needed here: put a stick or some such thing into a flame, and see whether it isn't burned more quickly at the edge of the flame than at its centre.

37. Things differ greatly in how susceptible to heat they are. Note first of all how even the bodies that are least susceptible of heat are warmed a little by faint heat. Even a piece of metal warms up a little if held for a while in your hand. So readily and

universally is heat transmitted and aroused—without the warmed body changing its appearance.

Item 38: How to Make a Thermometer

38. Of all the substances we know, the one that gets and gives heat most readily is air. You can see this in calendar glasses [= 'thermometers'], which are made thus.

- Take a glass flask with a rounded belly and a narrow elongated neck;
- attach along its neck a strip of paper marked with as many degrees as you choose;
- use a flame to warm the flask's belly; then
- turn the flask upside down and lower it—mouth down and belly up—into another glass vessel containing water. Let the mouth of the inserted flask touch the bottom of the receiving vessel, with the flask's neck resting lightly on the mouth of the receiving vessel. (It may help if you apply a little wax to the mouth of the receiving vessel, but not so as to create a seal. We are going to be dealing with very light and delicate movements, and we don't want them to be blocked because air can't pass through.

·There is your equipment; and now here is the experiment·. The air in the flask was expanded by the heat of the flame; and now it will contract as the flask cools down, so that eventually the flask will contain the same amount of air as before but in a smaller space than that of the entire flask. The remaining space in the flask will be filled with water from the receiving vessel. You'll see that the colder the day is the more the air contracts and thus the more water is drawn up into the flask; and the markings on the flask's neck will let you measure these changes. Air is much more finely sensitive to heat and cold than we are with our sense of touch; a ray of sunshine, or the heat of your breath, not to mention the heat of your hand placed on the top of the glass, will lower the level of the water by a perceptible amount. Yet I think that animal spirits are even more sensitive to heat and cold, or would be if they weren't deadened by the mass of the body.

39. Next to air, the bodies that seem to me most sensitive to heat are ones that have recently been compressed by cold, such as snow and ice; for it takes only a very gentle heat to start them melting. Next, perhaps, comes mercury. Then fatty substances such as oil, butter, etc.; then wood; then water; and lastly stones and metals, which are slow to heat, especially internally. These ·slow-to-heat substances·, however, once they are hot, remain so for a long time; so much so that when an intensely hot brick, stone or piece of iron is plunged into a basin of water it remains too hot to touch for nearly a quarter of an hour.

40. The less mass a body has the more quickly it grows warm from being near a hot body; which shows that all heat in our experience is in some way opposed to tangible matter.

41. To the human sense of touch, heat is a variable and relative thing; tepid water feels hot to a hand that was cold, and cold to a hand that was hot.

14. From the above tables you can see how impoverished my ·natural· history is. I have ·frequently· offered, in place of proven history and solid instances, mere traditions and hearsay. I have always noted the doubtful credibility and authority of these, ·but that doesn't alter the fact that they represent *gaps* in my natural history, which is why· I have often had to resort to saying things like 'Try an experiment' and 'We should inquire'.

The next post in the sequence will be posted Thursday, November 7 at latest by 4:00pm PT.

A First Sketch of the Nature of Heat (Novum Organum Book 2: 15-25)

This is the eleventh post in the Novum Organum sequence. For context, see the sequence introduction. For the reading guide, see earlier posts in the sequence.

We have used Francis Bacon's Novum Organum in the version presented atwww.earlymoderntexts.com. Translated by and copyright to Jonathan Bennett. Prepared for LessWrong by Ruby.

[[In the previous section, Bacon introduced his "three tables": his careful collection of data and observations that are core to building up his scientific method.

These tables are:

1) A table of *presence* which lists many examples where phenomena of interest in presence, e.g. many examples of things where we have heat.

2) A table of *nearby essence*. His example is heat and to discriminate its true heat, Bacon looks for examples of things that resemble those in the table of presence yet are lacking the heat. For the example, the light of the moon (cold) is contrasted with the light of the sun (hot) which is interesting given they are both heavenly bodies.

3) A table of *degrees* or *comparison* where are examples are brought where the amount of perceived heat differs in degree between things. This is also useful in discriminating the true underlying cause and and nature of heat.]]

Aphorism Concerning the Interpretation of Nature: Book 2: 15-25

15. The job of these three tables is—in the terminology I have chosen—to *present instances to the intellect*. After the presentation has been made, induction itself must get to work. After looking at each and every instance we have to find a nature which

- is always present when the given nature (in our present case: heat) is present,
- is always absent when the given nature is absent,
- always increases or decreases with the given nature, and
- is a special case of a more general nature

(I mentioned this last requirement in **4**). If the mind tries to do this •affirmatively from the outset (which it always does when left to itself), the result will be fancies and guesses and ill-defined notions and axioms that have to be adjusted daily. (Unless like the schoolmen* we choose to fight in defence of error; and in that case how well an axiom fares will depend ·not on how much truth it contains but· on the ability and strength of its defender.) It is for God (who designed and gave the forms), and perhaps also for angels and higher intelligences, to have an immediate •affirmative knowledge of forms straight away. This is certainly more than man can do. We have to proceed at first through

[[*Schoolmen: Aristotelian scholars.]]

16.

[Bacon will now be likening scientific procedure to a kind of chemical analysis, in which various components of a complex liquid are distilled off by heat, leaving the residue in which we are interested.]

So we have to subject the nature ·in which we are interested· to a complete dismantling and analysis, not by fire but by the mind, which is a kind of divine fire. The first task of true induction (as regards the discovery of forms) is to reject or exclude natures that

- are not found in some instance where the given nature is present, or
- are found in some instance from which the given nature is absent, or
- are found to increase in some instance when the given nature decreases, or
- are found to decrease when the given nature increases.

After these rejections and exclusions have been properly made, and all volatile opinions have been boiled off as vapour, there will remain at the bottom of the flask (so to speak) an affirmative form that is solid, true and well defined. It doesn't take long to *say* this, but the process of *doing* it is lengthy and complex. Perhaps I'll manage not to overlook anything that can help in the task.

17. I have to warn you—and I can't say this too often!—that

When you see me giving so much importance to *forms*, do *not* think I am talking about the 'forms' that you have been used to thinking about.

·Treating my forms as your 'forms' in the present context would be wrong in two ways·. **(1)** I'm not talking here about composite forms, the ones in which various simple natures are brought together in the way the universe brings them together—the likes of the forms of *lion*, *eagle*, *rose*, *gold*, and so on. It will be time to treat of these when we come to *hidden* processes and *hidden* microstructures, and the discovery of them in so-called *substances* or composite natures.

(2) In speaking of ·forms or· simple natures, I'm not talking about *abstract* forms and ideas which show up unclearly in matter if indeed they show up in it at all. When I speak of 'forms' I mean simply the objective real-world laws of pure action* that govern and constitute any simple nature—e.g. heat, light, weight—in every kind of matter and in anything else that is susceptible to them. Thus the 'form of heat' or the 'form of light' is the same thing as the *law* of heat or the *law* of light; and I shan't ever use abstractions through which I step back from things themselves and their operations.

[*Bacon doesn't explain *actus purus*. In each of its other three occurrences he connects it with *laws*, and his meaning seems to be something like: 'the laws governing the pure actions of individual things, i.e. the things they do because of their own natures independently of interference from anything else'. If x does A partly because of influence from something else y, then x is not purely •active in respect of A because y's influence gives A a certain degree of •passivity. From here on, *actus purus* will be translated by 'pure action'.]

[In the next sentence, 'rarity' is cognate with 'rare' in the sense of 'thin, attenuated, not *dense*'.] So when I say (for instance) in the investigation of the form of heat

- 'reject rarity ·from the list of simple natures that constitute heat·', or
- 'rarity does not belong to the form of heat',

·I may seem to be talking about an abstract property *rarity*, but what I am saying can just as well be said without any noun purporting to refer to any such abstraction. For· those statements are tantamount to

- 'It is possible for us to make a dense body hot', or
- 'It is possible for us keep or remove heat from a rare body',

·where 'rarity' and 'denseness' give way to 'rare' and 'dense'·.

You may think that my forms also are somewhat abstract, as they mix and combine things that are very different from one another. ·This complaint might come from your noticing that·

- the heat of heavenly bodies seems to be very unlike the heat of fire,
- the relatively durable redness of a rose (say) is very unlike the ·transient shimmering· redness that appears in a rainbow, an opal, or a diamond, and the different kinds of death—by drowning, burning, stabbing, stroke, starvation—are very unalike;

yet they share the nature of heat, redness and death respectively. If you *do* have that thought, this shows that your mind is captive to •habit, to •things taken as a whole ·and not subject to analysis or bit-by-bit examination·, and to •men's opinions. For it is

quite certain that these things, however unalike they may be, agree in the form or law that governs heat, redness and death (respectively); and human power can't possibly be freed from the common course of nature, and expanded and raised to new powers and new ways of operating, except by discovering of forms of this kind. This •union of nature is the most important thing I have to talk about; but when I have finished with it I shall take up, in the proper place, the •divisions and veins of nature, both the ordinary ·superficial· ones and also the ones that are more internal and true. ·By the 'union of nature' I mean the coming together of disparate things under a single form. By the 'division and veins of nature' I mean the complexities in which disparate structures and functions come together in a single thing·.

18. I should now provide an example of the exclusion or rejection of natures that are shown by the Tables of Presentation not to belong to the form of heat. All that is needed for the rejection of any nature ·from the form we are investigating· is a single ·contrary· instance from one of the tables; for what I have said makes it obvious that any conjecture ·of the type 'Nature N belongs to form F'· is knocked out by a single contrary instance. But I shall sometimes cite two or three such instances—for clarity's sake and to provide practice in using the tables.

An example of exclusion or rejection of natures from the form of heat:

(1) reject: elemental nature **because of** the rays of the sun

(2) reject: heavenly nature **because of** ordinary fire, and especially underground fires, which are the most completely cut off from the rays of heavenly bodies

(3) reject: how fine-grained a body's structure is **because of** the fact that all kinds of bodies (minerals, vegetables, skin of animals, water, oil, air, and so on) become warm simply by being close to a fire or other hot body

(4) reject: being attached to or mixed with another body that is hot **because of** the fact that red-hot iron and other metals give heat to other bodies without losing any of their own weight or substance

(5) reject: light and brightness **because of** boiling water and ·hot· air, and also metals and other solids that become hot but not enough to burn or glow

(6) reject: light and brightness **because of** the rays of the moon and other heavenly bodies (except the sun)

(7) reject: light and brightness **because of** the fact that red-hot iron has more heat and less brightness than the flame of alcohol

(8) reject: rarity **because of** very hot gold and other metals that have the greatest density

(9) reject: rarity **because of** air, which remains rare however cold it becomes

(10) reject: change in a body's size or shape **because of** red-hot iron, which doesn't become larger or change its shape

(11) reject: change in a body's size or shape **because of** the fact that in thermometers, and the like, air expands without becoming noticeably warmer

(12) reject: destructive nature, or the forceful addition of any new nature **because of** the ease with which all bodies are heated without any destruction or noticeable alteration

(13) reject: expanding or contracting motion of the body as a whole **because of** the agreement and conformity of similar effects displayed by both heat and cold

(14) reject: the *basic* natures of things (as distinct from properties they have through antecedent causes) **because of** the creation of heat by rubbing things together There are other natures beside these; I'm not offering complete tables, but merely examples.

Not a single one of the 'reject:' natures belongs to the form of heat. In all our dealings with heat we can set those aside.

19. The process of exclusion is the foundation of true induction; but the induction isn't completed until it arrives at something affirmative. Of course the excluding part ·of our work· is itself nothing like complete, and it can't be so at the beginning. For exclusion is, obviously, the *rejection of simple natures*; so how can we do it accurately when we still don't have sound and true notions of simple natures? Some of the notions that I have mentioned (such as the notions of *elemental nature*, *heavenly nature* and *rarity*) are vague and ill defined. I'm well aware of, and keep in mind, how great a work I am engaged in (namely making the human intellect a match for things and for nature); so I am not satisfied with what I have said up to here. I now go further, and devise and supply more powerful aids for the intellect—aids that I shall now present. In the interpretation of nature the mind should be thoroughly prepared and shaped up, so that it will at each stage settle for the degree of certainty that is appropriate there, while remembering (especially at the beginning) that the answer to 'What is *this* that we have before us?' depends to a great extent on what will come of it later on.

20. Truth emerges more quickly from error than from confusion, ·which implies that it can be worthwhile to aim for clarity even at the risk of going wrong·. So I think it will be useful, after making and weighing up three tables of first presentation (such as I have exhibited), to give the intellect permission to try for an interpretation of nature of the affirmative kind on the strength of the instances given in the tables and also of any others that may turn up elsewhere. I call this kind of attempt •'permission for the intellect' or •'sketch of an interpretation' or—·the label I shall actually use in this work·—•the 'first harvest'.

A first harvest of the form of heat

Something that is perfectly clear from what I have said earlier should be borne in mind here, namely that the •form of a thing is present in each and every instance of the thing; otherwise it wouldn't be its •form; from which it follows that there can't be any counter-instances ·where the thing is present and the form isn't·. Still, the form is much more conspicuous and obvious in •some instances than in others, namely in •those where the nature of the form is less restrained and obstructed and limited by other natures. Instances of •this kind I call 'luminous' or (·most of the time·) 'revealing' instances. So now let us proceed to the first harvest concerning the form of heat.

> In each and every case of heat the cause of the nature of which heat is a special case appears to be **motion**. This shows most conspicuously in flames, which are on the move all the time, and in boiling or simmering liquids, which are also

constantly in motion. It is also shown when motion stirs heat up or increases it—as happens with bellows and with wind (Third Table 29) and with other kinds of motion (28 and 31). It is also shown when fire and heat are extinguished by any strong compression, which checks and stops the motion (see 30 and 32). It is shown also by the fact that all bodies are destroyed or at any rate significantly changed by any fire or strong heat, which makes it quite clear that heat causes a tumult and agitation and lively motion in the internal parts of a body, which gradually moves it towards dissolution.

In certain cases heat generates motion and in certain cases motion generates heat, but *that* isn't what I am saying when I say that motion is like a genus in relation to heat ·as one of its species·. What I mean is that heat itself *is* nothing but motion of a certain specific kind; I'll tell you soon what special features of a case of motion make it qualify as a case of heat. Before coming to that, though I shall present three cautions that may be needed to avoid unclarity about some of the terms I shall be using.

·First caution: My topic is *heat*, not *heat-as-we-feel-it*·. Heat as we feel it is a relative thing—relative to humans, not to the world; and it is rightly regarded as merely the effect of heat on the animal spirits. Moreover, in itself it is variable, since a single body induces a perception of cold as well as of heat, depending on the condition of the senses. This is clear from the item 41 in the Third Table [here].

·Second caution: My topic is *heat*, not *the passing on of heat*·. Don't confuse the *form* of heat with the *passing on* of heat from body to body, for *heat* is not the same as *heating*. Heat is produced by the motion of rubbing something that at first has no heat; and that's enough to show that the transmission of heat is no part of the form of *heat*. And even when something is heated by another hot thing's coming close to it, that doesn't come from the form of heat; rather, it depends entirely on a higher and more general nature, namely the nature of *assimilation* or *self-multiplication*, a subject that needs to be investigated separately. [See here.]

·Third caution: My topic is *heat*, not *fire*·. Our notion of fire is a layman's one, and is useless ·for scientific purposes·. What it counts as 'fire' is the combination of heat and brightness in a body, as in ordinary flame and bodies that are red hot. [Red-heat is treated as a kind of 'burning' in item 24 here.]

Having guarded against verbal misunderstandings, I now at last come to the true specific differences which qualify a case of •motion (·genus·) to count as a case of •heat (·species·).

The **first** difference then is this. Heat is an *expansive* motion in which a body tries expand to a greater size than it had before. We see this most clearly in flame, where the smoke or thick vapour obviously expands into flame.

It also appears in any boiling liquid, which can be seen to swell, rise and bubble, and goes on expanding itself until it turns into a body that is far bigger than the liquid itself, namely into steam, smoke, or air.

It appears also in all wood and ·other· flammable things, where there is sometimes sweating and always evaporation.

It is shown also in the melting of metals. Because they are highly compact, metals don't easily expand and dilate; but their *spirit* expands, and wants to expand further; so it forces and agitates the lumpier parts into a liquid state. If the metal becomes hotter still, it dissolves and turns much of itself into a volatile substance.

It appears also in iron or rocks: they don't liquefy or run together, but they become soft. Similarly with wooden sticks, which become flexible when slightly heated in hot ashes.

But this kind of motion is best seen in air, which a little heat causes to expand—see Third Table 38 [here].

It shows up also in the contrary nature, namely *cold*. For cold contracts all bodies—makes them shrink—so that in a hard frost nails fall out of walls, bronze vessels crack, and heated glass when exposed to cold cracks and breaks. Similarly, a little cooling makes air contract, as in 38. But I'll say more about this when I deal properly with cold.

It's no wonder that heat and cold should exhibit many actions in common (for which see the Second Table 32). This first specific difference ·helping to denarcate the species *heat* within the genus *motion*· concerns a feature of heat that is diametrically opposite to a feature of *cold*, because whereas heat expands cold contracts; but the third and fourth differences (still to come) belong to the natures both of heat and of cold.

The **second** difference is a special case of the first, namely: Heat is a motion in which the hot body •expands while it •rises. This is a case of mixed motion, of which there are many—e.g. an arrow or javelin •rotates while it •flies forward. Similarly the motion of heat is an expansion as well as a movement upwards.

This difference appears when you put a poker into a fire. If you put it in upright and hold it by the top, it soon burns your hand; if you put it in at the side or from below, it takes longer to burn your hand.

It can also be seen in fractional distillation, which men use for ·extracting essences from· delicate flowers that soon lose their scent. It has been found in practice that one should place the fire not below ·the distilling retort· but above it, so as to burn less. For all heat, not only flame, tends upward.

This should be tried out on the opposite nature, cold, to learn whether cold contracts a body downward as heat expands it upward. Here's how to do it. Take two iron rods or glass tubes of exactly the same dimensions, warm them a little and place a sponge steeped in cold water or snow at the bottom of the one, and a similar one at the top of the other. I think that the end of the rod that has snow at the top will cool sooner than the end of the rod with snow at the bottom—the opposite of what happens with heat.

The **third** specific difference is this: heat is a motion that isn't expansive uniformly through the whole ·hot· body, but only through its smaller particles; and this expansion ·in any one particle· is at the same time checked, repelled, and beaten back ·by the expansions of other particles·, so that there's a back-and-forth motion within the body, which is irritated by all the quivering, straining and struggling that goes on; and from that comes the *fury* of fire and heat.

This ·specific· difference is most apparent in flames and in boiling liquids, where there are continual little rises and falls across their surface.

It also shows up in bodies that are so compact that when heated or ignited they don't swell or expand in bulk—e.g. in red-hot iron, in which the heat is very sharp.

And it is apparent in hearth fires, which burn brightest in the coldest weather.

It also shows in the fact that when the air in a calendar glass [see item 38 here] expands without obstacles or counter-pressures, and thus expands at the same rate throughout, there is no perceptible heat. Also when an enclosed body of ·compressed· air escapes, no great heat is observed; that is because although the air bursts out with the greatest force, its only expansive motion is a motion of *the whole*, with no back-and-forth motions in *the particles*. . . .

It is also shown in this, that all burning acts on minute pores in the body in question, so that burning digs into the body, penetrating and pricking and stinging it like the points of countless needles. . . .

And this third specific difference is shared with the nature of *cold*. For in cold the contractive motion is checked by a tendency to expand, just as in heat the expansive motion is checked by a tendency to contract. Thus, whether the particles of a body work inward or outward, the mode of action is the same though the degree of strength may be very different; because on the surface of the earth we don't have anything that is intensely cold. [See item (3) here.]

The **fourth** specific difference is a special case of the third. It is that the motion of pricking and penetrating must be fairly fast, not sluggish, and must go by particles—very small ones but a bit bigger than the smallest.

This difference is apparent when you compare the effects of •fire with the effects of •time or age. Age or time makes things wither, consumes and undermines them, reduces them to ashes, just as much as fire does, though it acts on even smaller particles than fire acts on; because that motion is very slow and acts on very tiny particles, there is no detectable heat.

It is also shown by comparing the dissolution ·in acids· of iron and gold. Gold is dissolved without any heat being stirred up, whereas iron, when it is dissolved about as quickly as gold, starts up a violent heat. This is because the solvent for gold enters the gold gently and works at a level of very small particles, so that the particles of the gold give way easily; whereas the solvent for iron enters the iron roughly and forcibly, and the particles of the iron are more stubborn.

It is also apparent in some gangrenes and cases of rotting flesh, which don't arouse much heat or pain because the rotting process operates at the level of such tiny particles.

I offer this as the •first harvest—or •sketch of an interpretation—concerning the form of heat, made by way of •permission to the intellect [these three labels are introduced in **20** here.].

The form or true definition of heat can be derived from this first harvest. (I'm talking about heat considered absolutely, not heat relative to the senses.) Here it is, briefly:

- •Heat is an expansive motion that is resisted, and that fights its way through the smaller particles ·of the hot body·.

Special case of this expansion:

- •While expanding in all directions ·the hot body· has a tendency to rise.

Special case of the struggle through the particles:

- It is not very slow; rather it is fast and has some force.

This tells us how in practice to create heat. Here is the story:

> In some natural body, arouse a motion to expand; and repress this motion and turn it back on itself so that the expansion doesn't proceed evenly, but partly succeeds and is partly held back.

If you do that you will undoubtedly generate heat. It makes no difference whether

- the body is made of earthly elements or contains heavenly substances,
- is luminous or opaque,
- is rare or dense,
- is spatially expanded or still of its original size,
- tends towards dissolution or keeps its original condition,
- is animal, vegetable, or mineral (water, oil or air),

or any other substance that is capable of the motion described. Sensible heat is the same, but considered with reference to the senses. Let us now proceed to further aids.

[That last remark refers to the 'aids' that were promised in **19** here; the first such 'aid' has been **20**. A reminder about 'the tables of first presentation':

- the first table, of essence and presence, starts here;
- the second table, of divergence or nearby absence, starts here;
- the third table, of degrees or of comparison, starts here;
- 'the table of exclusion or rejection' starts here;
- 'the first harvest' starts here.

This reminder may be useful as a guide to Bacon's next remark.]

21. So much for the tables of •first presentation and of •rejection or exclusion, and the •first harvest based on them. Now we have to proceed to the other aids to the intellect in the interpretation of nature and in true and perfect induction. I'll present them in terms of heat and cold whenever tables are appropriate; but when only a few examples are needed I'll take them from all over the place, so as to give my doctrine as much scope as possible without creating confusion.

[We are about to meet the phrase 'privileged instances'. The Latin *praerogativa instantarum* strictly means 'privilege of instances', but Bacon always handles it as though it stood for a kind of instance, not a kind of privilege. The use of 'privilege' to translate *praerogativa* is due to Silverthorne, who relates it to the *centuria praerogativa* in ancient republican Rome—the aristocrats' privilege of voting first and thus having the best chance to influence the votes of others.]

My topics will be, in this order:

1. privileged instances

2. supports for induction

3. the correcting of induction

4. adapting the investigation to the nature of the subject

5. which natures should be investigated first, and which later

6. the limits of investigation, or a synopsis of all natures in the universe

7. practical consequences

8. preparations for investigation

9. the ascending and descending scale of axioms.

[There are twenty-seven classes of privileged instances, some with a number of sub-classes. Bacon's discussion of them runs to the end of the work. The other eight topics were to have been dealt with in later instalments of the Great Fresh Start, which he never wrote.]

22. Class 1 of privileged instances: **solitary instances**. Those are ones in which the nature we are investigating

> appears in things that have *nothing else* in common with other things that have that nature,

or ones in which the nature we are investigating

> does not appear in things that have *everything else* in common with other things that do have that nature.

·I put these first · because it is clear that they save us from detours, leading quickly and securely to *exclusions*, so that a few solitary instances are as good as many.

Suppose for example that we are investigating the nature of colour: in that context prisms, crystals, dew-drops and the like, which make colours in themselves and project them outside themselves onto a wall, are solitary instances. For they have nothing else in common with the colours inherent in flowers, coloured stones, metals, woods, etc.—i.e. nothing but colour. From which we can easily draw the conclusion that colour is merely a modification of the light that the object takes in. With prisms, crystals etc. the light is modified by the different angles at which the light strikes the body; with flowers, coloured stones etc. it is modified by various textures and microstructures of the body. These instances are •resemblance-solitary.

In that same investigation of light: the distinct veins of white and black in a piece or marble, and the variegation of colour in flowers of the same species, are solitary instances. The black and white streaks in marble have almost everything in common except their colour, and so do the streaks of pink and white in a carnation. From this we can easily infer that colour doesn't have much to do with the intrinsic nature—·the microscopic fine texture·—of a body, but only on the quasi-mechanical arrangement of its larger parts. These instances are •difference-solitary. . . .

23. Class 2 of privileged instances: **shifting instances**. Those are ones where the nature under study is •shifting towards being produced when it didn't previously exist, or •shifting towards non-existence when it existed before. Shifting instances, whichever kind of shift they involve, are always twofold, or rather it is one instance in which the movement is continued until it reaches the opposite state.

[At this point some material is removed, and will be reinserted as a paragraph between *asterisks* below; it is easier to understand there than it would be here.]

Here is an example of a shifting instance. Suppose we are investigating *whiteness*: shifting instances in which the shift is towards production or existence ·of whiteness· are

> unbroken glass shifting to powdered glass ordinary water shifting to water shaken up to make foam.

Plain glass and water are transparent, not white, whereas pounded glass and foaming water are white, not transparent. So we have to ask what happened to the glass or water in this shift. Obviously, the form of whiteness is brought in by the pounding of the glass and the shaking of the water; but we find that nothing has occurred except the breaking up of the glass and water into small parts, and the introduction of air. So we have this result:

> Two bodies, air and water (or: air and glass) which are more or less transparent come to exhibit whiteness as soon as they are broken up into small bits ·and the bits are mixed·, this whiteness being brought about by the unequal refraction of the rays of light.

This is a big step towards discovering the form of whiteness.

*Such instances don't just lead quickly and securely to exclusions, but also narrow down the search for the affirmation or the form itself ['exclusion' and 'affirmation' are introduced in **15** here]. For the form of a thing must be something that is introduced by a shift, or removed and wiped out by a shift in the other direction. Of course every exclusion supports some affirmation, but the support is more direct when the exclusion comes from one case rather than from a number of cases. And my discussion has made it clear that the form that comes to light in a single instance leads the way to the discovery of it in all the rest. And the simpler the shift, the more value we should attach to the instance. And another thing: shifting instances are of great value in the practical part ·of scientific inquiry·: a shifting instance exhibits •the form ·under investigation· linked with •the cause of its existing (or the cause of its not existing); that provides great clarity in one instance and an easy transition to others. But shifting instances create a certain danger against which I should warn you: they may lead us to link the form too closely to its efficient cause, and so encourage a false view of the form, drawn from a view of the efficient cause. The efficient cause is always understood to be merely the vehicle for or bearer of the form. It is not hard to avoid this danger in a properly conducted exclusion.*

I should give an example of this danger. A mind that is led astray by efficient causes of this sort will too easily conclude that •air is always required for the form of whiteness, or that •whiteness is generated only by transparent bodies—both of which are entirely false, and refuted by numerous exclusions. What *will* be found (setting air and the like aside) is this:

> all the particles that affect vision are equal
>
> transparent
>
> unequal and simply textured
>
> white
>
> unequal with complex regular texture

any but black

unequal and complex in an irregular way

black

So now we have before us an instance with a shift to the •production of the nature under study, namely whiteness. For an instance that shifts to the •destruction of the same nature of whiteness, consider breaking up foam or melting snow. In each case, what you then have is *water*, not broken into little particles and not mixed with air, and this sheds whiteness and puts on transparency.

It's important to note that shifting instances include not only those in which the nature under study shifts toward production or toward destruction, but also those in which the nature shifts towards increasing or decreasing. It's because these also contribute to revealing the form, as can be clearly seen from the definition of *form* that I have given ·in **17**·, and the Table of Degrees [starting here]. Paper that is white when dry become less white and nearer to being transparent when it is wetted—i.e. when air is excluded and water introduced. The explanation of what is happening here is analogous to the explanation of the first shifting instances.

24. Class 3 of privileged instances: **revealing instances**, which I have already mentioned in the first harvest concerning heat, and which I also call 'luminous' and 'freed and predominant'. They are the instances in which the nature under study is revealed

naked and standing on its own feet, and also
at its height and in full strength,

not muffled by any impediments. This is either because •there aren't any impediments in this instance or because •there are some but the nature we are studying is present in such strength that it holds them down and pushes them around. ·Here is the background *setting* for these revealing instances·:

> Every body is capable of having many forms or natures linked together; they can crush, depress, break and bind one another so that the individual forms are obscured. But we find that in some subjects the nature under investigation stands out from the others, either because there are no obstacles or because its vigorous strength makes it prominent.

Instances of this kind reveal the form with special clarity.

But we should be careful in our handling of ·what seem to be· revealing instances, not rushing to conclusions. When something reveals a form very conspicuously and seems to force it on the notice of our intellect, we should view it with suspicion and should avail ourselves of a strict and careful exclusion ·of other potentially relevant features, rather than abruptly brushing them aside in our enthusiasm for the conspicuous nature that has attracted our attention·.

Suppose, for example, that we are investigating the nature of heat. As I said earlier [in item 38 here], the motion of expansion is the main element in the form of heat, and a revealing instance of *that* is a •thermometer. Although •flame obviously exhibits expansion, it doesn't show expansion as an ongoing process, because a flame can be so quickly snuffed out. Nor does •boiling water provide a good display of expansion in its own body ·*as water*· because it so easily turns into vapour or air. As for red-hot iron

and its like: they are so far from exhibiting expansion as an ongoing process that their expansion is almost imperceptible; that's because their spirit is being crushed and broken by the coarse and compact particles, which curb and subdue the expansion. But a thermometer clearly displays expansion in air, revealing it as conspicuous, progressive, and enduring rather than transitory.

To take another example: suppose the nature inquired into is *weight*. A revealing instance of weight is mercury. It is heavier than anything else except gold, which is only slightly heavier; and mercury does a better job of indicating the form of weight than gold does, because gold is solid and compact—features that seem to come from its *density*— whereas mercury is liquid and full of spirit despite being much heavier than the diamond and other bodies that are thought to be the most solid. This reveals that the form of heaviness or weight depends simply on the *quantity* of matter and not on how *compact* the body is.

25. Class 4 of privileged instances: **concealed instances**, which I also ·though not again in this work· call 'instances of the twilight'. They are pretty nearly the exact opposites of revealing instances. They exhibit the nature under investigation at its lowest strength, as though it were in its cradle, newly born, making its first attempts but buried under and subdued by a contrary nature. Still, such instances are very helpful in the discovery of forms; because just as

revealing instances lead easily to •specific differences,

so also

concealed instances are the best guides to •genera,

i.e. to the common natures of which the natures under investigation are merely special cases. ·That is to say, revealing instances help us to move down the classificatory table, concealed instances help us to move up·.

Suppose for example that the nature under investigation is •solidity or a thing's holding its shape, the opposite of which is •fluidity. Concealed instances of this are ones that exhibit some low level of shape-holding *in a fluid*—for example a bubble of water, which has a sort of shaped *skin* made of water. Similarly with trickling water: if the water keeps coming, the drops lengthen themselves out into a thin thread so as to keep the stream unbroken; and if there isn't enough water for that, the water falls in round drops, that being the shape that best preserves the water from breaking up ·into still smaller portions·. But the instant the thread of water stops and the drops begin, the water jumps back upwards so as to avoid breaking. And in metals, which when melted form thick fluids, the molten drops often jump back up and stay there. . . . The same kind of thing can be seen in the children's game when they take water, thicken it a little with soap, and blow it through a hollow reed: this combines the water with air so as to make a cluster of bubbles that is firm enough to be thrown some distance without breaking up. But foam and snow provide the best examples of this phenomenon. They become almost solid enough to be cut with a knife, although they are made out of two fluids—air and water. All of this pretty clearly indicates •that 'solid' and 'liquid' are ·not useful terms in the present context, because they are· layman's notions which relate ·not to the scientific facts about a thing but only to how it strikes· our senses. It also indicates •that in fact all bodies have a tendency to avoid being broken up, a tendency that is weak in homogeneous bodies (which is what fluids are), and stronger in bodies made up of different kinds of materials (·the ones the layman calls 'solid'·). That is because a body is bound together when heterogeneous

matter is introduced to it, whereas the insertion of homogeneous matter dissolves the body and makes it fall apart.

Here are three more examples. **(1)** Suppose that the nature we are investigating is the *attraction* or *coming together* of bodies. The best revealing instance of the form of this is the magnet. There is also the *non-attracting* nature—the contrary of the attracting one—and this can even be found in the same substance. Thus iron doesn't attract iron, lead doesn't attract lead, or wood wood, or water water.

[In what follows, an 'armed' magnet is one equipped with an 'armature' in the sense of 'a piece of soft iron placed in contact with the poles of the magnet, which preserves and increases the magnetic power; or any arrangement which produces the same result' (OED). Another such arrangement is an 'armature' in *our* sense of the word—coils of wire conducting electricity— but that wasn't discovered as a means of magnetism until two centuries later.]

Now a concealed instance ·of attraction· is provided by •a magnet armed with iron, or rather by •the iron in an armed magnet. Its nature is such that

> an armed magnet does not attract iron *from a distance* more powerfully than an unarmed magnet does,

whereas

> when the iron in an armed magnet *touches* some other iron, the magnet supports a far greater weight of iron than a simple unarmed magnet would.

This is because of the similarity of substances, iron on iron—an effect that was latent in the iron ·all along·, but was completely *concealed* before the magnet was brought into play. So it is clear that the form of coming-together is something that is lively and strong in the magnet, feeble and latent in iron. **(2)** It has been noticed that small wooden arrows with no iron points, shot from large guns into the sides of ships or into other wooden targets, penetrate more deeply than they would if they were tipped with iron. This is because of the similarity of substances, wood on wood, although this property had previously been latent in the wood—·only latent, and thus concealed·. **(3)** Similarly, whole bodies of air (water) don't obviously attract other bodies of air (water), but the likelihood of a bubble's bursting is increased when it is touched by another bubble. This is because of water's ·usually concealed· inclination to join with water, and air's to join with air. Such concealed instances (which are very useful, as I have said) show up most conspicuously in small portions of bodies. The reason for that is that larger masses follow more general forms, as I'll explain in due course.

Novum Organum: Introduction

In light of its value as a rationalist text, its historical influence on the progress of science, and its general expression of the philosophy and vision which guides LessWrong 2.0, the moderation team has seen fit to publish Novum Organum as a LessWrong sequence. (Image: the engraved title page.)

Quotes in this post are from Francis Bacon's Novum Organum in the version by Jonathan Bennett presented at www.earlymoderntexts.com

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In 1620, Francis Bacon's *Novum Organum* was published. Though the work might be succinctly described as Bacon's views on empiricism and inductivism, it is far more than a list of experimental steps to be followed. It is an entire epistemology and philosophy—possibly *the* epistemology and philosophy which underlay the Scientific Revolution.

Bacon was damning of the science of his time and preceding centuries. He saw the pseudo-empirical syllogistic paradigm as deeply flawed and incapable of making progress.

> If those doctrines ·of the ancient Greeks· hadn't been so utterly like a plant torn up by its roots, and had remained attached to and nourished by the womb of nature, the state of affairs that we have seen to obtain for two thousand years—namely *the sciences stayed in the place where they began, hardly changing, not getting any additions worth mentioning, thriving best in the hands of their first founders and declining from then on*—would never have come about. (**74**) [1]

He also believed that the unaided human mind was incapable of getting far on its own.

> Nearly all the things that go wrong in the sciences have a single cause and root, namely: while wrongly admiring and praising the powers of the human mind, we don't look for true helps for it. (**9**)

> Not much can be achieved by the naked hand or by the unaided intellect. Tasks are carried through by tools and helps, and the intellect needs them as much as the hand does. (**2**)

> When the intellect of a sober, patient, and grave mind is left to itself (especially in a mind that isn't held back by accepted doctrines), it ventures a little way along the right path; but it doesn't get far, because without guidance and help it isn't up to the task, and is quite unfit to overcome the obscurity of things. (**21**)

Nonetheless, he was optimistic that if the old doctrines were abandoned, *idols of the mind* (i.e., biases, fallacies, and confusions) were cleared out, and his precise, careful empirical method was followed by a community of scholars, then no knowledge was out of reach and humanity would eventually achieve all of the most splendid discoveries.

> Until now men haven't lingered long with •experience; they have brushed past it on their way to the ingenious •theorizings on which they have wasted unthinkable amounts of time. But if we had someone at hand who could answer our questions of the form 'What are the facts about this matter?', it wouldn't take many years for us to discover all causes and complete every science. (**112**)

The human mind is fallible and flawed—"like a distorting mirror,'' Bacon says—yet its biases can be overcome. Through adherence to properly looking at the world, such that if "the road from the senses to the intellect [is] well defended with walls along each side," then a scientific community can figure out the world and even reach Utopia.

This a decidedly LessWrong worldview.

Indeed, by my reading, Bacon possessed in some form a large number of concepts employed on LessWrong, not limited to: confirmation bias, motivated cognition, the bottom line, mind-projection fallacy, positive bias, entangled evidence, carving reality at its joints, fake causality, worshipping ignorance, idea inoculation, the surprisingly detailedness of reality, inferential distance, incentives, and dissolving confused language. He even spoke of the *appropriate degrees of certainty* for each stage of an inquiry and deliberately used epistemic statuses!

Novum Organum was Bacon's monumental attempt to explain all of the above: how and why the existing scientific methods were entirely broken, why nobody had noticed until then, what the alternative paradigm was, and a vision for a community of scholars and institutions which could help discover all scientific truths.

Covering biases and empiricism as it does, Novum Organum is highly instructive as a rationalist text. Yet why read Bacon when we've got the Sequences, Codex, and the

rest of modern LessWrong? I answer that it's worthwhile because there's a focus and immediacy to a text whose author wasn't writing abstractly, but direly wanted to redirect all the scientific efforts of his time to be more productive.

There's an impressiveness to someone grappling with how to do science at a point when so much less was known about the world. Compared to us, Bacon's time was one of extreme mystery. Recall that he was writing before Boyle, Newton, Maxwell, or Darwin. He did not have access to theories of thermodynamics, electromagnetism, evolution, or atomic physics. They hadn't even invented the mercury thermometer in his time. He earnestly tried to figure out simply "what is heat?" and by use of his meticulous empiricism correctly inferred it was just something to do with motion—150 years before phlogiston theory was laid to rest and with access to only primitive air-based thermometers!

We get to look back and point to all that modern science has done over the centuries to make us feel enthusiastic. Four hundred years ago, Bacon's enthusiasm came entirely from his ability to look forward.

There is also perhaps a validation of the LessWrong worldview to be found in Bacon. Bacon was a symbolic figure of the Scientific Revolution. Inspirational to the Royal Society and many others. Historical credit allocation is hard, but it seems more likely than not that Bacon gets a good deal of credit in bringing about the Scientific Revolution. Seemingly, many of the same ideas that we cherish now were read by the scholars who first read Bacon and kicked off the modern scientific era. If only people hadn't stopped reading Bacon in the original after a few generations.

Beyond his instruction in biases and empiricism, Bacon in an inspiration to the LessWrong 2.0 project [2] for his visions of how infrastructure and community are key to intellectual progress. Bacon saw intellectual progress as a technological [3] and collaborative endeavor, exactly as LessWrong 2.0 does.

At the technologies for individual thinking level, Bacon writes:

> Not much can be achieved by the naked hand or by the unaided intellect. Tasks are carried through by tools and helps, and the intellect needs them as much as the hand does. And just as the hand's tools either give motion or guide it, so ·in a comparable way· the mind's tools either point the intellect in the direction it should go or offer warnings. (**2**)

Bacon is further adamant that the process of science requires people to write their work down and share it. Perhaps this is obvious now, but Bacon was writing before the first scientific journal, indeed, he is credited as a major inspiration for the Royal Society whose philosophical transactions were the first scientific journal.

> Even after we have acquired and have ready at hand a store of natural history and experimental results such as is required for the work of the intellect, or of philosophy, still that is not enough. The intellect is far from being able to retain all this material in memory and recall it at will, any more than a man could keep a diary all in his head. Yet until now there has been more thinking than writing about discovery procedures—experimentation hasn't yet become literate! But a discovery isn't worth much if it isn't ·planned and reported· in writing; and when this becomes the standard practice, better things can be hoped for from experimental procedures that have at last been made literate. (**101**)

Yet another point, maybe, obvious to us now: the work of science can be split up among people.

> Unlike the work of sheerly thinking up hypotheses, proper scientific work can be done collaboratively; the best way is for men's efforts (especially in collecting experimental results) to be exerted separately and then brought together. Men will begin to know their strength only when they go this way—with one taking charge of one thing and another of another, instead of all doing all the same things. (**113)**

Though Bacon's greatest reference to collaborating and institution for knowledge perhaps comes from his utopian novel, *New Atlantis*. One character describes the fictional institution of Solomon's House:

> Ye shall understand (my dear friends) that amongst the excellent acts of that king, one above all hath the pre-eminence. It was the erection and institution of an Order or Society, which we call *Salomon's House*; the noblest foundation (as we think) that ever was upon the earth; and the lanthorn of this kingdom. It is dedicated to the study of the works and creatures of God. Some think it beareth the founder's name a little corrupted, as if it should be Solamona's House. But the records write it as it is spoken. So as I take it to be denominate of the king of the Hebrews, which is famous with you, and no stranger to us.

The novel goes into great depth about how the institution functions and all the roles different individuals play in the scientific process. According to Wikipedia, it is this vision which inspired Samuel Hartlib and Robert Boyle to found the Royal Society.

To conclude this introduction, I'll mention that Novum Organum is actually part two of six from Bacon's much larger, never-completed work, *Instauratio Magna*. The title is usually translated as *The Great Instauration* yet Bennett (whose translation of Novum Organum we are posting) translates it as *The Great Fresh Start*. Seems fitting to Bacon's intentions.

> It is pointless to expect any great advances in science from grafting new things onto old. If we don't want to go around in circles for ever, making 'progress' that is so small as be almost negligible, we must make a fresh start with deep foundations. (**31**)

Given the Scientific Revolution got going in earnest around his lifetime, I dare say he got what we he asked for.

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[1] Novum Organum consists two books each containing "aphorisms" which range in length from three lines to sixteen pages. A bold number on its own refers to an aphorism from Book 1 by default or Book 2 where the context is very clear. When unclear, aphorisms are referenced by a leading 1- or 2- to disambiguate, e.g 2-13 is the 13th aphorism in Book 2.

[2] Usually, we now call ourselves simply "LessWrong" but it feels important to disambiguate here since I cannot make claims to the vision for original LessWrong as founded in 2009 by Eliezer. It does seem clear that Eliezer was not influenced by Bacon in the same way that Habryka (LessWrong 2.0's team lead and core founder) has been.

[3] By *technological* I refer broadly to the creation of knowledge and tools that can be used for a specific purpose, including things like methodologies and procedures, not just physical artifacts. I would call a set of techniques for debiasing one's thinking and likewise training for how to moderate an online forum as both examples of technologies.

Novum Organum: Preface

Previously: Ruby's introduction to the Novum Organum sequence

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Ruby's Reading Guide

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>
> While the translator, Bennett, encloses his editorial remarks in a single pair of [brackets], I have enclosed mine in a [[double pair of brackets]].

Bennett's Reading Guide

> [Brackets] enclose editorial explanations. Small ·dots· enclose material that has been added, but can be read as though it were part of the original text. Occasional •bullets, and also indenting of passages that are not quotations, are meant as aids to grasping the structure of a sentence or a thought. Every four-point ellipsis . . . . indicates the omission of a brief passage that seems to present more difficulty than it is worth. Longer omissions are reported between brackets in normal-sized type.
>
> 'Organon' is the conventional title for the collection of logical works by Aristotle, a body of doctrine that Bacon aimed to replace. His title *Novum Organum* could mean 'The New Organon' or more modestly 'A New Organon'; the tone of the writing in this work points to the definite article.

Aphorism Concerning the Interpretation of Nature: Preface

by Francis Bacon

Those who have taken it on themselves to lay down the law of nature as something that has already been discovered and understood, whether they have spoken in simple confidence or in a spirit of professional posturing, have done great harm to philosophy and the sciences. As well as succeeding in •producing beliefs in people, they have been effective in •squashing and stopping inquiry; and the harm they have done by spoiling and putting an end to other men's efforts outweighs any good their own efforts have brought. Some people on the other hand have gone the opposite way, asserting that absolutely nothing can be known—having reached this opinion through dislike of the ancient sophists, or through uncertainty and fluctuation of mind, or even through being crammed with some doctrine or other. They have certainly advanced respectable reasons for their view; but zeal and posturing have carried

them much too far: they haven't •started from true premises or •ended at the right conclusion. The earlier of the ancient Greeks (whose writings are lost) showed better judgment in taking a position between

- one extreme: presuming to pronounce on everything,

and

- the opposite extreme: despairing of coming to understand anything.

My method is hard to practice but easy to explain. I propose to •establish *degrees* of certainty, to •retain ·the evidence of· the senses subject to certain constraints, but mostly to •reject ways of thinking that track along after sensation. In place of that, I open up a new and certain path for the mind to follow, starting from sense-perception. The need for this was felt, no doubt, by those who gave such importance to dialectics; their emphasis on dialectics showed that they were looking for aids to the intellect, and had no confidence in the innate and spontaneous process of the mind.

[Bacon's *dialectica*, sometimes translated as 'logic', refers more narrowly to the formalized and rule-governed use of logic, especially in debates.]

But this remedy did no good, coming as it did *after* the processes of everyday life had filled the mind with hearsay and debased doctrines and infested it with utterly empty idols. (·I shall explain 'idols' in **39–45**·.) The upshot was that the art of dialectics, coming (I repeat) too late to the rescue and having no power to set matters right, was only good for fixing errors rather than for revealing truth.

[Throughout this work, 'art' will refer to any human activity that involves techniques and requires skills.]

We are left with only one way to health—namely to start the work of the mind all over again. In this, the mind shouldn't be left to its own devices, but right from the outset should be guided at every step, as though a machine were in control.

Certainly if in mechanical projects men had set to work with their naked hands, without the help and power of tools, just as in intellectual matters they have set to work with little but the naked forces of the intellect, even with their best collaborating efforts they wouldn't have achieved—or even attempted—much. . . . Suppose that some enormous stone column had to be moved from its place (wanted elsewhere for some ceremonial purpose), and that men started trying to move it with their naked hands, wouldn't any sober spectator think them mad? If they then brought in more people, thinking that that might do it, wouldn't he think them even madder? If they then weeded out the weaker labourers, and used only the strong and vigorous ones, wouldn't he think them madder than ever? Finally, if they resolved to get help from the art of athletics, and required all their workers to come with hands, arms, and sinews properly oiled and medicated according to good athletic practice, wouldn't the onlooker think 'My God, they are trying to show *method* in their madness!'?

Yet that is exactly how men proceed in intellectual matters—with just the same kind of mad effort and useless combining of forces—when they hope to achieve great things either through their individual brilliance or through the sheer number of them who will co-operate in the work, and when they try through dialectics (which we can see as a kind of athletic art) to strengthen the sinews of the intellect. With all this study and effort, as anyone with sound judgment can see, they are merely applying the naked intellect; whereas in any great work to be done by the hand of man the only way to

increase the force exerted by each and to co-ordinate the efforts of all is through instruments and machinery.

Arising from those prefatory remarks, there are two more things I have to say; I want them to be known, and not forgotten. ·One concerns ancient *philosophers*, the other concerns modern *philosophy*·.

(1) If I were to declare that I could set out on •the same road as the ancient philosophers and come back with something better than they did, there would be no disguising the fact that I was setting up a rivalry between them and me, inviting a comparison in respect of our levels of excellence or intelligence or competence. There would nothing new in that, and nothing *wrong* with it either, for if the ancients got something wrong, why couldn't I—why couldn't *anyone*—point it out and criticise them for it? But that contest, however right or permissible it was, might have been an unequal one, casting an unfavourable light on my powers. So it is a good thing—good for avoiding conflicts and intellectual turmoil—that I can leave untouched the honour and reverence due to the ancients, and do what I plan to do while gathering the fruits of my modesty! There won't be any conflict here: my aim is to open up •a new road for the intellect to follow, a road the ancients didn't know and didn't try. I shan't be taking a side or pressing a case. My role is merely that of a guide who points out the road—a lowly enough task, depending more on a kind of luck than on any ability or excellence.

(2) That was a point about persons; the other thing I want to remind you of concerns the topic itself. Please bear this in mind: I'm not even slightly working to overthrow the philosophy [here = 'philosophy and science'] that is flourishing these days, or any other more correct and complete philosophy that has been or will be propounded. I don't put obstacles in the way of this accepted philosophy or others like it; ·let them go on doing what they have long done so well·—let them give philosophers something to argue about, provide decoration for speech, bring profit to teachers of rhetoric and civil servants! Let me be frank about it: the philosophy that I shall be advancing isn't much use for any of *those* purposes. It isn't ready to hand; you can't just pick it up as you go; it doesn't fit with preconceived ideas in a way that would enable it to slide smoothly into the mind; and the vulgar won't ever get hold of it except through its practical applications and its effects.

[In this work, 'vulgar' means 'common, ordinary, run-of-the-mill' (as in 'vulgar induction' **17**) or, as applied to people, 'having little education and few intellectual interests'.]

So let there be two sources of doctrine, two disciplines, two groups of philosophers, and two ways of doing philosophy, with the groups not being hostile or alien to each other, but bound together by mutual services. In short, let there be one discipline for cultivating the knowledge we have, and another for discovering new knowledge. This may be pleasant and beneficial for both. Most men are in too much of a hurry, or too preoccupied with business affairs, to engage with my way of doing philosophy—or they don't have the mental powers needed to understand it. If for any of those reasons you prefer the other way—·prefer cultivation to discovery·—I wish you all success in your choice, and I hope you'll get what you are after. But if you aren't content to stick with the knowledge we already have, and want

- to penetrate further,
- to conquer nature by works, not conquer an adversary by argument,
- to look not for nice probable opinions but for sure proven knowledge,

I invite you to join with me, if you see fit to do so. [In this context, ‘works’ are experiments.] Countless people have stamped around in nature’s outer courts; let us get across those and try to find a way into the inner rooms. For ease of communication and to make my approach more familiar by giving it a name, I have chosen to call one of these approaches ‘the mind’s **anticipation** ·of nature·’, the other ‘the **interpretation** of nature’.

[Throughout this work, ‘anticipation’ means something like ‘second-guessing, getting ahead of the data, jumping the gun’. Bacon means it to sound rash and risky; no one current English word does the job.]

I have one request to make, ·namely that my courtesies towards you, the reader, shall be matched by your courtesies to me·. I have put much thought and care into ensuring that the things I say will be not only true but smoothly and comfortably accepted by •your mind, however clogged •it is by previous opinions. It is only fair—especially in such a great restoration of learning and knowledge—for me to ask a favour in return, namely this: If you are led •by the evidence of your senses, or •by the jostling crowd of ‘authorities’, or •by arguments in strict logical form (which these days are respected as though they were the law of the land), to want to pass judgment on these speculations of mine, don’t think you can do this casually, while you are mainly busy with something else. Examine the matter thoroughly; go a little distance yourself along the road that I describe and lay out; make yourself familiar with the *subtlety* of things that our experience indicates; give your deeply-rooted bad mental habits a reasonable amount of time to correct themselves; and *then*, when you have started to be in control of yourself, use your own judgment—if you want to.

[Bacon doesn’t ever in this work address the reader at length. This version sometimes replaces ‘If anybody. . . ’ by ‘If you. . . ’, ‘Men should. . . ’ by ‘You should. . . ’ and so on, to make the thought easier to follow.]

The Inadequacy of Current Science (Novum Organum Book 1: 1-37)

This is the third post in the Novum Organum sequence. For context, see the sequence introduction .

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Aphorism Concerning the Interpretation of Nature: Book 1: 1–37

by Francis Bacon

1. Man, being nature's servant and interpreter, is limited in what he can do and understand by what he has observed of the course of nature—directly observing it or inferring things ·from what he has observed·. Beyond that he doesn't know anything and can't do anything.

2. Not much can be achieved by the naked hand or by the unaided intellect. Tasks are carried through by tools and helps, and the intellect needs them as much as the hand does. And just as the hand's tools either •give motion or •guide it, so ·in a comparable way· the mind's tools either •point the intellect in the direction it should go or • offer warnings.

3. Human knowledge and human power meet at a point; for where the cause isn't known the effect can't be produced. The only way to command nature is to obey it; and something that functions as the •cause in thinking about a process functions as the •rule in the process itself.

4. All that man can do to bring something about is to put natural bodies together or to pull them away from one another. The rest is done by nature working within.

5. The mechanic, the mathematician, the physician, the alchemist and the magician have all rubbed up against nature in their activities; but so far they haven't tried hard and haven't achieved much.

6. If something has never yet been done, it would be absurd and self-contradictory to expect to achieve it other than through means that have never yet been tried.

[[Similar: not every change is an improvement, but every improvement is a change.]]

7. If we go by the contents of •books and by •manufactured products, the mind and the hand seem to have had an enormous number of offspring. But all that variety consists in very fine-grained special cases of, and derivatives from, a few things that were already known; *not* in a large number of fundamental propositions.

8. Moreover, the works that have already been achieved owe more to chance and experiment than to disciplined sciences; for the sciences we have now are merely pretty arrangements of things already discovered, not ways of making discoveries or pointers to new achievements.

9. Nearly all the things that go wrong in the sciences have a single cause and root, namely: while wrongly admiring and praising the powers of the human mind, we don't look for true helps for it.

10. Nature is much subtler than are our senses and intellect; so that all those elegant meditations, theorizings and defensive moves that men indulge in are crazy—except that no-one pays attention to them.

[Bacon often uses a word meaning ‘subtle’ in the sense of ‘fine-grained, delicately complex’; no one current English word will serve.]

[[An especially good example of this point, that nature is far more "subtle" than our senses and mind, is the generally counterintuitive fact that our universe runs on quantum mechanics. In Can You Prove Two Particles Are Identical?, Eliezer points to this weird aspects of reality that one is very unlikely to discover without the empiricism/appropriate tools and methodology which Bacon is advocating for.]]

11. just as the sciences that we now have are useless for devising new inventions, the logic that we now have is useless for discovering new sciences.

[Bacon here uses *inventio* in two of its senses, as = ‘invent’ and as = ‘discover’.]

12. The logic now in use serves to •fix and stabilize errors based on the ideas of the vulgar, rather than to •search for truth. So it does more harm than good.

[[The next few aphorisms dealing with syllogism and axioms are made with reference to the Aristotelian 'scientific method.' In that classical approach, a few real-world examples are used to derive high-level universal rules or laws which are then operated on with logic to derive further conclusions. See this comment below for more detail.]

The leap from a few examples to high-level general principles is what Bacon is calling out when in **19** he speaks of 'swooping up' from particulars to general axioms. This is in contrast to his gradual, incremental, *inductive* method that starts with limited statements of rule and only slowly generalizes as more data is accumulated.]]

13. The syllogism isn’t brought to bear on the •basic principles of the sciences; it *is* applied to •intermediate axioms, but nothing comes of this because the syllogism is no match for nature’s subtlety. It constrains what you can *assent* to, but not what can *happen*.

[[These remarks bear resemblance to those in The Parable of Hemlock.]]

14. A •syllogism consists of •propositions, which consist of •words, which are stand-ins [*tesserae*, literally = ‘tickets’] for •notions. So the root of the trouble is this: If the notions are confused, having been sloppily abstracted from the facts, nothing that is built on them can be firm. So our only hope lies in true induction.

15. There is no soundness in ·our· notions, whether in logic or in natural science. These are not sound notions:

- substance, quality, acting, undergoing, being;

And these are even less sound:

- heavy, light, dense, rare, moist, dry, generation, corruption, attraction, repulsion, element, matter, form

and so on; all of those are fantastical and ill-defined.

[‘Rare’ = ‘opposite of dense’. Generation is the coming into existence of living things; corruption is rotting or falling to pieces, and so refers to the going out of existence of

living things. For the next sentence: a ‘lowest species’ is one that doesn’t further divide into subspecies.]

16. ·Our· notions of the lowest species (*man*, *dog*, *dove*) and of the immediate perceptions of the senses (*hot*, *cold*, *black*, *white*) don’t seriously mislead us; yet even they are sometimes confusing because of how matter flows and things interact. As for all the other notions that men have adopted—they are mere aberrations, not being caused by things through the right kind of abstraction.

17. The way •axioms are constructed is as wilful and wayward as the abstractions through which •notions are formed. I say this even about the principles that result from vulgar induction, but much more about the axioms and less basic propositions that the syllogism spawns.

18. The discoveries that have been made in the sciences up to now lie close to vulgar notions, scarcely beneath the surface. If we are to penetrate into nature’s inner and further recesses, we’ll need •a safer and surer method for deriving notions as well as axioms from things, as well as •an altogether better and more certain way of conducting intellectual operations.

19. There are and *can be* only two ways of searching into and discovering truth. **(1)** One of them starts with the senses and particular events and *swoops* straight up from them to the most general axioms; on the basis of these, taken as unshakably true principles, it proceeds to judgment and to the discovery of intermediate axioms. This is the way that people follow now. **(2)** The other derives axioms from the senses and particular events in a gradual and unbroken ascent, ·going *through* the intermediate axioms and· arriving *finally* at the most general axioms. This is the true way, but no-one has tried it.

[[Reminder that 'dialectics' is generally Bacon's term for logic, but he is seemingly specifically referring to the logic and processes followed in Aristotle's methods.]]

20. When the intellect is left to itself it takes the same way—namely **(1)**—that it does when following the rules of dialectics. For the mind loves to leap up to generalities and come to rest with them; so it doesn’t take long for it to become sick of experiment. But this evil, ·though it is present both in natural science and in dialectics·, is worse in dialectics because of the ordered solemnity of its disputations.

21. When the intellect of a sober, patient, and grave mind is left to itself (especially in a mind that isn’t held back by accepted doctrines), it ventures a little way along **(2)** the right path; but it doesn’t get far, because without guidance and help it isn’t up to the task, and is quite unfit to overcome the obscurity of things.

22. Both ways set out from the senses and particular events, and come to rest in the most general propositions; yet they are enormously different. For one of them **(1)** merely glances in passing at experiments and particular events, whereas the other **(2)** stays among them and examines them with proper respect. One **(1)** proceeds immediately to laying down certain abstract and useless generalities, whereas the other **(2)** rises by step by step to what is truly better known by nature.

[In calling something ‘known to nature’ Bacon means that it is a general law of nature; ‘better known by nature’ could mean ‘a more general law of nature’ or ‘a generality that is more completely lawlike’.]

23. There is a great difference between •the *idols* of the human mind and •the *ideas* of God's mind—that is, between •certain empty beliefs and •the true seals [= 'signs of authenticity'] and marks that we have found in created things.

24. There's no way that axioms •established by argumentation could help us in the discovery of new things, because the subtlety of nature is many times greater than the subtlety of argument. But axioms •abstracted from particulars in the proper way often herald the discovery of new particulars and point them out, thereby returning the sciences to their active status.

25. The axioms that are now in use are mostly made so that they *just* cover the items from which they arise, namely thin and common-or-garden experiences and a few particulars of the commonest sorts, so it is no wonder if they don't lead to new particulars. ·And it's not only the axioms, but also the way they are handled, that is defective·. If some unexpected counter-example happens to turn up, the axiom is rescued and preserved by some frivolous distinction, rather than (the truer course) being amended.

> [[Once upon a time, the philosophers of Plato's Academy claimed that the best definition of human was a "featherless biped". Diogenes of Sinope, also called Diogenes the Cynic, is said to have promptly exhibited a plucked chicken and declared "Here is Plato's man." The Platonists promptly changed their definition to "a featherless biped with broad nails". - Similarity Clusters]]

26. To help me get my ideas across, I have generally used different labels for human reason's two ways of approaching nature: the customary way I describe as *anticipating nature* (because it is rash and premature) [Note from the preface: throughout this work, 'anticipation' means something like 'second-guessing, getting ahead of the data, jumping the gun'. Bacon means it to sound rash and risky; no one current English word does the job.] and the way that draws conclusions from facts in the right way I describe as *interpreting* nature.

27. Anticipations are a firm enough basis for consent, for even if men all went mad in the same way they might agree one with another well enough.

[[consent = agreement]]

28. Indeed, anticipations have much more power to win assent than interpretations do. They are inferred from a few instances, mostly of familiar kinds, so that they immediately brush past the intellect and fill the imagination; whereas interpretations are gathered from very various and widely dispersed facts, so that they can't suddenly strike the intellect, and must seem weird and hard to swallow—rather like the mysteries of faith.

[[Bacon appears to be saying that the easy, quick, rash science is easy convince people of since it has low inferential distance owing to it being derived from a few familiar examples; in contrast, his difficult and true science built on many observations and facts has high inferential distance, causing it to seem strange and weird.]]

29. Anticipations and dialectics have their place in sciences based on opinions and dogmas, because in those sciences the aim is to be master of •what people believe but not of •the facts.

30. Even if all the brains of all the ages come together, collaborate and share their results, no great progress will ever be made in science by means of anticipations. That is because errors that are rooted in the first moves that the mind makes can't be cured later on by remedial action, however brilliant.

31. It is pointless to expect any great advances in science from grafting new things onto old. If we don't want to go around in circles for ever, making 'progress' that is so small as be almost negligible, we must make a fresh start with deep foundations.

['Fresh start' translates *instauratio*, from the verb *instauro* = 'make a fresh start (on a ceremony that has been wrongly performed)'. Bacon planned a six-part work on science and its philosophy and methods, which he called his *Instauratio magna*—his Great Fresh Start. There are other informal mentions of fresh starts in **38** and **129**, and the Great Fresh Start is referred to in **92** and each of **115–117**. Bacon died six years after publishing the present work. It is Part 2 of the Great Fresh Start, and the only Part he completed.]

32. This is not to attack the honour of the ancient authors or indeed of anyone else, because I am comparing not •intelligences or •competences but •ways ·of proceeding in the sciences·; and the role I have taken on is that of a guide, not a judge.

33. This must be said outright: anticipations (the kind of reasoning that is now in use) can't pass judgment on my method or on discoveries arising from it; for I can't be called on to submit to the sentence of a tribunal which is itself on trial!

34. It won't be easy for me to deliver and explain my message, for things that are in themselves *new* will be understood on analogy with things that are *old*.

35. Borgia said that when the French marched into Italy they came with chalk in their hands to •mark out their lodgings, not with weapons to •force their way in. Similarly, I want my doctrine to enter quietly into the minds that are fit to receive it and have room for it. ·Forcing my way in with weapons, so to speak, won't work· because refutations—·and more generally *arguments* pro and con·—can't be employed when what's at stake is a difference of view about first principles, notions, and even forms of demonstration.

36. There remains for me only one way of getting my message across. It is a simple way, namely this: I must lead you to the particular events themselves, and to the order in which they occur; and you for your part must force yourself for a while to lay aside your •notions and start to familiarize yourself with •facts.

37. Those who deny that anything can be known for sure •start off their thinking in something like my way, but where they •end up is utterly different from and opposed to where I end up. They say that *nothing can be known*, period. I say that *not much can be known about nature by the method that is now in use*. And then they go on to destroy the authority of the senses and the intellect, whereas I devise and supply helps for them.

The next post in the sequence, Book 1: 38-52 (Idols of the Mind Pt. 1), will be posted Tuesday, September 24 at latest by 4:00pm PDT.

Idols of the Mind Pt. 1 (Novum Organum Book 1: 38–52)

This is the fourth post in the Novum Organum sequence. For context, see the sequence introduction.

We have used Francis Bacon's Novum Organum in the version presented at www.earlymoderntexts.com. Translated by and copyright to Jonathan Bennett. Prepared for LessWrong by Ruby.

Ruby's Reading Guide

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Bennett's Reading Guide

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Aphorism Concerning the Interpretation of Nature: Book 1: 38–52

by Francis Bacon

38. The idols and false notions that now possess the human intellect and have taken deep root in it don't just •occupy men's minds so that truth can hardly get in, but also when a truth *is* allowed in they will •push back against it, stopping it from contributing to a fresh start in the sciences. This can be avoided only if men are forewarned of the danger and do what they can to fortify themselves against the assaults of these idols and false notions.

39. There are four classes of idols that beset men's minds, and to help me in my exposition I have given them names. I call the first class **idols of the tribe**, the second **idols of the cave**, the third **idols of the market place**, and the fourth **idols of the theatre**.

40. The proper way to keep idols at bay and to drive them off is, no doubt, to form ideas and axioms by true induction. But it is very useful just to point the idols out; for •the truth about the idols serves •the interpretation of nature in the way that •the truth about argumentative fallacies serves •ordinary logical argumentation.

41. The **idols of the tribe** have their foundation in human nature itself—in the tribe known as 'mankind'. It is not true that the human senses are the measure of things; for all perceptions—of the senses as well as of the mind—reflect the perceiver rather than the world. The human intellect is like a distorting mirror, which receives light-rays irregularly and so mixes its own nature with the nature of things, which it distorts.

[[This is something of a reference to the Mind Projection Fallacy.]]

42. The **idols of the cave** are the idols of the individual man. In addition to the errors that are common to human nature in general, everyone has his own personal cave or den that breaks up and corrupts the light of nature. This may come from factors such as these:

- his own individual nature,
- how he has been brought up and how he interacts with others,
- his reading of books and the influence of writers he esteems and admires,
- differences in how his environment affects him because of differences in his state of mind—whether it is busy thinking about something else and prejudiced against this intake or calm and open-minded.

So that the human spirit is distributed among individuals in ways that make it variable and completely disorderly—almost a matter of luck. Heraclitus was right: men look for sciences in ·their own individual· lesser worlds, and not in the greater world that they have in common.

[[Related: Epistemic Luck. However, I believe Bacon's eventual thesis is that even though luck may determine your starting point, proper use of tools, i.e. empiricism,

can lead to correct conclusions even if you started out unlucky.]]

43. There are also idols formed by men's agreements and associations with each other (·I have in mind especially the agreements that fix the meanings of words·). I call these **idols of the market place**, because that is where men come together and do business. ·Such transactions create idols· because •men associate by talking to one another, and •the uses of words reflect common folks' ways of thinking. It's amazing how much the intellect is hindered by wrong or poor choices of words. The definitions or explanations that learned men sometimes use to protect themselves ·against such troubles· don't at all set the matter right: words plainly force and overrule the intellect, throw everything into confusion, and lead men astray into countless empty disputes and idle fancies.

[[Bacon grokked that misuses of words were a great cause of confusion. He probably would have like the A Human's Guide to Words Sequence. See Where to Draw the Boundary? and 37 Ways That Words Can Be Wrong.]]

44. Lastly, there are idols that have come into men's minds from various philosophical dogmas and from topsy-turvy laws of demonstration. I call these **idols of the theatre**, because I regard every one of the accepted systems as the staging and acting out of a fable, making a fictitious staged world of its own. I don't say this only about the systems that are currently fashionable, or only about the ancient sects and philosophies; many other fables of the same kind may still be written and produced, seeing that errors can be widely different yet have very similar causes. And I'm saying this not only about whole systems but also about a good many principles and axioms in ·individual· sciences—ones that have gathered strength through tradition, credulity, and negligence. But these various kinds of idols will have to be discussed more clearly and at greater length if the human intellect is to be adequately warned against them. ·I'll start with the idols of the tribe, which will be my topic until the end of **52**·.

45. The human intellect is inherently apt to •suppose the existence of more order and regularity in the world than it •finds there. Many things in nature are unique and not like anything else; but the intellect devises for them non-existent parallells and correspondences and relatives. That is how it comes about •that all the heavenly bodies are thought to move in perfect circles. . . ., •that fire. . . .has been brought in as one of the elements, to complete the square with the other three elements—·earth, air, water·—which the senses detect, and •that the 'elements' (as they are called) are arbitrarily said to differ in density by a factor of ten to one. And so on for other dreams. And these fancies affect not only ·complex· propositions but also simple notions.

[[People see patterns everywhere, many that aren't there.]]

46. Once a human intellect has adopted an opinion (either as something it *likes* or as something generally accepted), it draws everything else in to confirm and support it. [[Confirmation bias.]] Even if there are more and stronger instances against it ·than there are in its favour·, the intellect either •overlooks these or •treats them as negligible or •does some line-drawing that lets it shift them out of the way and reject them. This involves a great and pernicious prejudgment by means of which the intellect's former conclusions remain inviolate.

> A man was shown a picture, hanging in a temple, of people who had made their vows and escaped shipwreck, and was asked '*Now* do you admit the power of the

gods?' He answered with a question: 'Where are the pictures of those who made their vows and then drowned?'

[[A correct identification of selection bias/survivorship bias/anthropic bias.]]

It was a good answer! That's how it is with all superstition— involving astrology, dreams, omens, divine judgments, and the like, Men get so much pleasure out of such vanities that they notice the •confirming events and inattentively pass by the more numerous •disconfirming ones. This mischief insinuates itself more subtly into philosophy and the sciences: there, when a proposition has found favour it colours other propositions and brings them into line with itself, even when they ·in their undisguised form· are sounder and better than it is. Also, apart from the pleasure and vanity that I have spoken of, the human intellect is perpetually subject to the special error of being moved and excited more by affirmatives than by negatives; whereas it *ought* to have the same attitude towards each. Indeed, when it is a matter of establishing a true axiom, it's the negative instance that carries more force.

[[The idea of looking for disconfirming negative instances is expounded in Positive Bias: Look Into the Dark.]]

47. The greatest effect on •the human intellect is had by things that strike and enter the mind simultaneously and unexpectedly; it is these that customarily fill—*inflate*!—the imagination; and then •it feigns and supposes that everything else is somehow, though •it can't see how, similar to those few things that have taken it by storm. ['Feign' translates the Latin *fingo*, which is the source for the English word 'fiction'.] But the intellect is altogether slow and unfit for the journey to distant and heterogeneous instances which put axioms to the test—like testing something by fire—unless it is forced to do so by severe laws and overruling authority.

48. The human intellect is never satisfied; it can't stop or rest, and keeps searching further; but all to no purpose. That's why we can't conceive of any end or limit to the world—why we always virtually *have* to have the thought of something beyond ·any candidate for the role of world's end·. And we can't conceive, either, of how eternity has flowed down to the present day. ·A plausible story about this says that time is infinite in both directions, and the present is just a point along this infinite line. But· the commonly accepted idea of infinity in time past and in time to come can't be sustained, for it implies that •one infinity is greater than another, and that •one infinity is getting used up and tending to become finite. The infinite divisibility of lines is a source of a similar network of difficulties arising from our thought's inability ·to reach a resting-place·. But this inability interferes even worse in the discovery of causes, ·and here is how·.

The most general principles in nature have to be brute facts, just as they are discovered, and can't be derived from any ·still more general or basic· cause. Yet the restless human intellect still looks for something

(**Latin:** *notiora* = 'better known', **probably short for:** *natura notiora* = 'better known to nature', **actually meaning:** 'more general and/or basic' [see note in **22**])— ·something to explain why they are true·.

Then in that ·doomed· struggle for something further off, it ·finds itself defeated, and instead· falls back on something that is nearer at hand, namely on *final causes*—·i.e. on the notion of what a principle is *for*, what *purpose* explains its being true·. Science has been enormously messed up by this appeal to final causes, which obviously come

from the nature of man rather than from the nature of the world—·that is, which project the scientist's own purposes *onto* the world rather than finding purposes *in* it·.

[[Similarly another case of Mind Projection Fallacy.]]

To look for causes of the most general principles is to do science in an ignorant and frivolous way—just as much as *not* looking for causes of subordinate and less general truths.

49. The human intellect doesn't burn with a dry [here = 'uncontaminated'] light, because what the person *wants* and *feels* gets pumped into it; and that is what gives rise to the 'please-yourself sciences'. For a man is more likely to believe something if he would like it to be true. Therefore he rejects:

- difficult things because he hasn't the patience to research them,
- sober and prudent things because they narrow hope,
- the deeper things of nature, from superstition,
- the light that experiments can cast, from arrogance and pride (not wanting people to think his mind was occupied with trivial things),
- surprising truths, out of deference to the opinion of the vulgar.

In short, there are countless ways in which, sometimes imperceptibly, a person's •likings colour and infect his •intellect.

[[This aphorism calls out the general behavior of motivated cognition.]]

50. But what contributes most to the blockages and aberrations of the human intellect is the fact that the ·human· senses are dull, incompetent and deceptive. The trouble is this: things that strike the senses outweigh other things— more important ones—that don't immediately strike them. That is why people stop *thinking* at the point where their *eyesight* gives out, paying little or no attention to •things that can't be seen—for example, all the •workings of the spirits enclosed in tangible bodies. Nor do they pay attention to all the subtler changes of microstructure in the parts of coarser substances (which are vulgarly called 'alterations' though they are really extremely small-scale •movements). And yet unless these two things—·the workings of spirits, and subtle changes of form in bodies·—can be searched out and brought into the light, nothing great can be achieved in nature in the way of practical applications. A third example: the essential nature of our common air, and of all the many bodies that are less dense than air, is almost unknown. For the senses by themselves are weak and unreliable; and instruments for extending or sharpening them don't help much. All the truer kind of *interpretation* of nature comes about through instances and well-designed experiments: the senses pass judgment on the experiment, and the experiment passes judgment on nature, on the facts.

[Bacon's many uses of the word *schematismus* show that for him a body's *schematismus* is its fine-grained structure. This version will always use 'microstructure', but be aware that Bacon doesn't use a word with the prefix 'micro'. •Also, here and throughout, 'spirits' are extremely finely divided gases or fluids, *not* mental items of any kind.]

51. The human intellect is inherently prone to make abstractions, and it feigns an unchanging essence for things that are in flux. But better than •abstracting from nature is •dissecting it; which is what Democritus and his followers did, getting deeper into nature than anyone since. What we should be attending to is *matter*, its microstructures and changes of microstructure, and *actus purus*, and the laws of

action or motion. ·The alternative to studying *matter* is to study *forms*, but· forms are fabrications of the human mind, unless you want to call the laws of action 'forms'.

[Bacon doesn't explain *actus purus*. In each of its other three occurrences he connects it with *laws*, and his meaning seems to be something like: 'the laws governing the pure actions of individual things, i.e. the things they do because of their own natures independently of interference from anything else'. If x does A partly because of influence from something else y, then x is not purely •active in respect of A because y's influence gives A a certain degree of •passivity. From here on, *actus purus* will be translated by 'pure action'.]

52. Those, then, are the idols of the tribe, as I call them— the idols that ·arise from human nature as such. More specifically, they· arise from the human spirit's •regularity of operation, or its •prejudices, or its •narrowness, or its •restlessness, or •input from the feelings, or from the •incompetence of the senses, or from •the way the senses are affected.

The next post in the sequence, Book 1: 53-68 (Idols of the Mind Pt. 2), will be posted Thursday, September 26 at latest by 4:00pm PDT.

Idols of the Mind Pt. 2 (Novum Organum Book 1: 53-68)

This is the fifth post in the Novum Organum sequence. For context, see the sequence introduction.

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Aphorism Concerning the Interpretation of Nature: Book 1: 53–68

by Francis Bacon

53. The idols of the cave—·my topic until the end of **58**·— arise from the particular mental and physical make-up of the individual person, and also from upbringing, habits, and chance events. There are very many of these, of many different kinds; but I shall discuss only the ones we most need to be warned against—the ones that do most to disturb the clearness of the intellect.

54. A man will become attached to one particular science and field of investigation either because •he thinks he was its author and inventor or because •he has worked hard on it and become habituated to it. But when someone of this kind turns to *general* topics in philosophy ·and science· he wrecks them by bringing in distortions from his former fancies. This is especially visible in Aristotle, who made his natural science a mere bond-servant to his logic, rendering it contentious and nearly useless. The chemists have taken a few experiments with a furnace and made a fantastic science out of it, one that applies to hardly anything. . . .

[In this work ‘chemists’ are alchemists. Nothing that we would recognize as chemistry existed.]

[[We might see Bacon here as claiming that "seeing everything as a nail" can be very harmful.]]

55. When it comes to philosophy and the sciences, minds differ from one another in one principal and fairly radical way: some minds have more liking for and skill in •noting differences amongst things, others are adapted rather to •noting things’ resemblances. The •steady and acute mind can concentrate its thought, fixing on and sticking to the subtlest distinctions; the •lofty and discursive mind recognizes and puts together the thinnest and most general resemblances. But each kind easily goes too far: one by •grasping for ·unimportant· differences between things, the other by •snatching at shadows.

56. Some minds are given to an extreme admiration of antiquity, others to an extreme love and appetite for novelty. Not many have the temperament to steer a middle course, not pulling down sound work by the ancients and not despising good contributions by the moderns. The sciences and philosophy have suffered greatly from this, because these attitudes to antiquity and modernity are not *judgments* but mere *enthusiasms*. Truth is to be sought not in •what people like or enjoy in this or that age, but in •the light of nature and experience. The •former is variable, the •latter is eternal. So we should reject these enthusiasms, and take care that our intellect isn’t dragged into them.

57. When you think ·hard and long and uninterruptedly· about nature and about bodies in their simplicity—·i.e. think of topics like *matter as such*·—your intellect will be broken up and will fall to pieces. When on the other hand you think ·in the same way· about nature and bodies in all their complexity of structure, your intellect will be

stunned and scattered. The difference between the two is best seen by comparing the school of Leucippus and Democritus with other philosophies. For the members of that school were so busy with the ·general theory of· particles that they hardly attended to the structure, while the others were so lost in admiration of the structure that they didn't get through to the simplicity of nature. What we should do, therefore, is alternate between these two kinds of thinking, so that the intellect can become *both* penetrating *and* comprehensive, avoiding the disadvantages that I have mentioned, and the idols they lead to.

58. Let that kind of procedure be our prudent way of keeping off and dislodging the idols of the cave, which mostly come from

- intellectual· favouritism (**54**),
- an excessive tendency to compare or to distinguish (**55**),
- partiality for particular historical periods (**56**), or
- the largeness or smallness of the objects contemplated (**57**).

Let every student of nature take this as a general rule for helping him to keep his intellect balanced and clear: when your mind seizes on and lingers on something with special satisfaction, treat it with suspicion!

59. The idols of the market place are the most troublesome of all—idols that have crept into the intellect out of the contract concerning words and names [Latin *verborum et nominum*, which could mean 'verbs and nouns'; on the contract, see **43**]. Men think that their reason governs words; but it is also true that words have a power of their own that reacts back onto the intellect; and this has rendered philosophy and the sciences sophistical and idle. Because words are usually adapted to the abilities of the vulgar, they follow the lines of division that are most obvious to the vulgar intellect. When a language-drawn line is one that a sharper thinker or more careful observer would want to relocate so that it suited the true divisions of nature, words stand in the way of the change. That's why it happens that when learned men engage in high and formal discussions they often end up arguing about words and names, using definitions to sort them out—thus •ending where, according to mathematical wisdom and mathematical practice, it would have been better to •start! But when it comes to dealing with natural and material things, definitions can't cure this trouble, because the definitions themselves consist of words, and those words beget others. So one has to have recourse to individual instances. . . .

[[Bacon grokked that misuses of words were a great cause of confusion. He probably would have like the A Human's Guide to Words Sequence. See Where to Draw the Boundary? and 37 Ways That Words Can Be Wrong.]]

60. The idols that words impose on the intellect are of two kinds. (1) There are names of things that don't exist. Just as there are things with no names (because they haven't been observed), so also there are names with no things to which they refer—these being upshots of fantastic ·theoretical· suppositions. Examples of names that owe their origin to false and idle theories are 'fortune', 'prime mover', 'planetary orbits', and 'element of fire'. This class of idols is fairly easily expelled, because you can wipe them out by steadily rejecting and dismissing as obsolete all the theories ·that beget them·.

[[See Empty Labels.]]

(2) Then there are names which, though they refer to things that do exist, are confused and ill-defined, having been rashly and incompetently derived from realities.

Troubles of this kind, coming from defective and clumsy abstraction, are intricate and deeply rooted. Take the word ‘wet’, for example. If we look to see how far the various things that are called ‘wet’ resemble one other, we’ll find that ‘wet’ is nothing but than a mark loosely and confusedly used to label a variety of states of affairs that can’t be unified through any constant meaning. For something may be called ‘wet’ because it

- easily spreads itself around any other body,
- has no boundaries and can’t be made to stand still,
- readily yields in every direction.
- easily divides and scatters itself,
- easily unites and collects itself,
- readily flows and is put in motion,
- readily clings to another body and soaks it,
- is easily reduced to a liquid, or (if it is solid) easily melts.

Accordingly, when you come to apply the word, if you take it in one sense, flame is wet; if in another, air is not wet; if in another, fine dust is wet; if in another, glass is wet. So that it is easy to see that the notion has been taken by abstraction only from water and common and ordinary liquids, without proper precautions.

Words may differ in *how* distorted and wrong they are. One of the •least faulty kinds is that of names of substances, especially names that

- are names of lowest species, ·i.e. species that don’t divide into sub-species·, and
- have been *well* drawn ·from the substances that they are names of·.

·The drawing of substance-names and -notions from the substances themselves *can* be done well or badly. For example·, our notions of chalk and of mud are good, our notion of earth bad. •More faulty are names of events: ‘generate’, ‘corrupt’, ‘alter’. •The most faulty are names of qualities: ‘heavy’, ‘light’, ‘rare’, ‘dense’, and the like. (I exclude from this condemnation names of qualities that are immediate objects of the senses.) Yet in each of these categories, inevitably some notions are a little better than others because more examples of them come within range of the human senses.

61. The idols of the theatre ·which will be my topic until the end of **68**· are not innate, and they don’t steal surreptitiously into the intellect. Coming from the fanciful stories told by philosophical theories and from upside-down perverted rules of demonstration, they are openly proclaimed and openly accepted. Things I have already said imply that there can be no question of *refuting* these idols: where there is no agreement on premises or on rules of demonstration, there is no place for argument.

·AN ASIDE ON THE HONOUR OF THE ANCIENTS·

This at least has the advantage that it leaves the honour of the ancients untouched ·because I shall not be *arguing against* them. I shall be *opposing* them, but· there will be no disparagement of them in this, because the question at issue between them and me concerns only *the way*. As the saying goes: a lame man on the right road outstrips the runner who takes a wrong one. Indeed, it is obvious that a man on the wrong road goes further astray the faster he runs. ·You might think that in claiming to be able to do better in the sciences than they did, I must in some way be setting myself up as brighter than they are; but it is not so·. The course I propose for discovery in the sciences leaves little to the acuteness and strength of intelligence, but puts all intelligences nearly on a level. My plan is exactly like the drawing of a straight line or a perfect circle: to do it free-hand you need a hand that is steady and

practised, but if you use a ruler or a compass you will need little if anything else; and my method is just like that.

·END OF ASIDE·

But though particular counter-arguments would be useless, I should say something about •the classification of the sects whose theories produce these idols, about •the external signs that there is something wrong with them, and lastly •about the causes of this unhappy situation, this lasting and general agreement in error. My hope is that this will make the truth more accessible, and make the human intellect more willing to be cleansed and to dismiss its idols.

62. There are many idols of the theatre, or idols of theories, and there can be and perhaps will be many more. For a long time now two factors have militated against the formation of new theories ·in philosophy and science·.

- Men's minds have been busied with religion and theology.
- Civil governments, especially monarchies, have been hostile to anything new, even in theoretical matters; so that men have done that sort of work at their own peril and at great financial cost to themselves—not only unrewarded but exposed to contempt and envy.

If it weren't for those two factors, there would no doubt have arisen many other philosophical sects like those that once flourished in such variety among the Greeks. Just as many hypotheses can be constructed regarding the phenomena of the heavens, so also—and even more!—a variety of dogmas about the phenomena of philosophy may be set up and dug in. And something we already know about plays that poets put on the stage is also true of stories presented on the philosophical stage —namely that fictions invented for the stage are more compact and elegant and generally liked than true stories out of history!

What has gone wrong in philosophy is that it has attended in great detail to a few things, or skimpily to a great many things; either way, it is based on too narrow a foundation of experiment and natural history, and decides on the authority of too few cases. **(1)**Philosophers of the reasoning school snatch up from experience a variety of common kinds of event, without making sure they are getting them right and without carefully examining and weighing them; and then they let meditation and brain-work do all the rest. **(2)** Another class of philosophers have carefully and accurately studied a few experiments, and have then boldly drawn whole philosophies from *them*, making all other facts fit in by wildly contorting them. **(3)** Yet a third class consists of those who are led by their faith and veneration to mix their philosophy with theology and stuff handed down across the centuries. Some of these have been so foolish and empty-headed as to have wandered off looking for knowledge among spirits and ghosts. So there are the triplets born of error and false philosophy: philosophies that are **(1)** sophistical, **(2)** empirical, and **(3)** superstitious.

[To explain Bacon's second accusation against Aristotle in **63**: A word 'of the second intention' is a word that applies to items of thought or of language (whereas things that are out there in the world independently of us are referred to by words 'of the first intention'). Now Aristotle in his prime held that the soul is not *a substance* but rather *a form*: rather than being an independently existing thing that is somehow combined with the rest of what makes up the man, the soul is a set of facts about how the man acts, moves, responds, and so on. Bacon has little respect for the term 'form': in **15** he includes it among terms that are 'fantastical and ill-defined', and in **51** he

says that ‘forms are fabrications of the human mind’. This disrespect seems to underlie the second accusation; the class of *forms* is not a class of independently existing *things* but rather a class of muddy and unfounded *ways of thinking and talking*, so that ‘form’ is a word of the second intention.]

63. The most conspicuous example of **(1)** the first class was Aristotle, whose argumentative methods spoiled natural philosophy. He

- made the world out of categories;
- put the human soul, the noblest of substances, into a class based on words of the second intention;
- handled the issues about density and rarity (which have to do with how much space a body takes up) in terms of the feeble distinction between what does happen and what could happen;
- said that each individual body has one proper motion, and that if it moves in any other way this must be the result of an external cause,

and imposed countless other arbitrary restrictions on the nature of things. He was always less concerned about the inner truth of things than he was about providing answers to questions—*saying* something definite. This shows up best when his philosophy is compared with other systems that were famous among the Greeks. For

- the homogeneous substances of Anaxagoras,
- the atoms of Leucippus and Democritus,
- the heaven and earth of Parmenides,
- the strife and friendship of Empedocles, and
- Heraclitus’s doctrine of bodies’ being reduced to the perfectly homogeneous condition of fire and then remolded into solids,

all have a touch of natural philosophy about them—a tang of the nature of things and experience and bodies. Whereas in Aristotle’s physics you hear hardly anything but the sounds of logical argument—involving logical ideas that he reworked, in a realist rather than a nominalist manner, under the imposing name of ‘metaphysics’. Don’t be swayed by his frequent mentions of experiments in his *On Animals*, his *Problems*, and others of his treatises. For he didn’t consult experience, as he should have done, *on the way to* his decisions and first principles; rather, he first *decided* what his position would be, and *then* brought in experience, twisting it to fit his views and making it captive. So on this count Aristotle is even more to blame than his modern followers, the scholastics, who have abandoned experience altogether.

64. The **(2)** empirical school of philosophy gives birth to dogmas that are more deformed and monstrous than those of the sophistical or reasoning school. The latter has as its basis the •light of vulgar notions; it’s a faint and superficial light, but it is in a way •universal, and applies to many things. In contrast with that, the empirical school has its foundation in the •narrowness and •darkness of a few experiments. Those who busy themselves with these experiments, and have infected their imagination with them, find such a philosophy to be probable and all but certain; everyone else finds them flimsy and incredible. A notable example of this ·foolishness· is provided by the alchemists and their dogmas; these days there isn’t much of it anywhere else, except perhaps in the philosophy of Gilbert. Still, I should offer a warning relating to philosophies of this kind. If my advice ever rouses men to take experiments seriously and to bid farewell to sophistical doctrines, then I’m afraid that they may—I foresee that they *will*—be in too much of a hurry, will leap or fly ·from experiments straight· to generalizations and principles of things, risking falling into

just the kind of philosophy I have been talking about. We ought to prepare ourselves against this evil now, ·well in advance·.

65. The corruption of philosophy by **(3)** superstition and input from theology is far more widespread, and does the greatest harm, whether to entire systems or to parts of them. ·Systems thus afflicted are just nonsense judged by ordinary vulgar standards, but that doesn't protect men from accepting them, because· the human intellect is open to influence from the imagination as much as from vulgar notions, ·and in these philosophies it is the imagination that wields the power·. Whereas the contentious and sophistical kind of philosophy combatively *traps* the intellect, this ·superstitious· kind, being imaginative and high-flown and half-poetic, *coaxes* it along. For men—especially intelligent and high-minded ones—have intellectual ambitions as well as ambition of the will.

A striking example of this sort of thing among the Greeks is provided by Pythagoras, though ·his form of it wasn't so dangerous, because· the superstition that he brought into it was coarser and more cumbrous ·than many·. Another example is provided by Plato and his school, whose superstition is subtler and more dangerous. Superstition turns up also in parts of other philosophies, when they

- introduce abstract forms—·i.e. forms that aren't the forms *of* anything·,

and when they do things like

- speaking of 'first causes' and 'final causes' and usually omitting *middle* causes.

[Bacon's point is: They discuss the first cause of the whole universe, and the end or purpose for which something happens (its 'final cause'), but they mostly ignore ordinary *causes* such as spark's causing a fire. Putting this in terms of first-middle-final seems to be a quiet joke].

We should be *extremely* cautious about this. There's nothing worse than the *deification* of error, and it is a downright plague of the intellect when empty nonsense is treated with veneration. Yet some of the moderns have been so tolerant of this emptiness that they have—what a shallow performance!—tried to base a system of natural philosophy on the first chapter of Genesis, on the book of Job, and other parts of the sacred writings, 'seeking the living among the dead' [Luke 24:5]. This makes it more important than ever to keep down this ·kind of philosophy·, because this unhealthy mixture of human and divine gives rise not only to •fantastic philosophy but also to •heretical religion. It is very proper that we soberly give our faith only to things that *are* the faith.

66. So much for the mischievous authority of systems founded on •vulgar notions, on •a few experiments, or on •superstition. I should say something about bad choices of what to think *about*, especially in natural philosophy. In the mechanical arts the main way in which bodies are altered is by composition or separation; the human intellect sees this and is infected by it, thinking that something like it produces all alteration in the universe. This gave rise to •the fiction of *elements* and of their coming together to form natural bodies. Another example: When a man surveys nature working freely, he encounters different species of things—of animals, of plants, of minerals—and that leads him smoothly on to the opinion that nature contains certain *primary forms* which nature intends to work with, and that all other variety comes from •nature's being blocked and side-tracked in her work, or from •conflicts between different species—conflicts in which one species turns into another. To the first of these theories we owe ·such intellectual rubbish as· *first qualities of the elements*; to the second we owe

occult properties and *specific virtues*. Both of them are empty short-cuts, ways for the mind to come to rest and not be bothered with more solid pursuits. The medical researchers have achieved more through their work on the second qualities of matter, and the operations of attracting, repelling, thinning, thickening, expanding, contracting, scattering, ripening and the like; and they would have made much greater progress still if *it weren't for a disaster that occurred. The two short-cuts that I have mentioned (elementary qualities and specific virtues) snared the medical researchers, and spoiled what they did with their correct observations in their own field.

[The passage flagged by asterisks expands what Bacon wrote, in ways that the small-dots system can't easily indicate.]

It led them either •to treating second qualities as coming from highly complex and subtle mixture of first or elementary qualities, or •to breaking off their empirical work prematurely, not following up their observations of second qualities with greater and more diligent observations of third and fourth qualities.* ·This is a bigger disaster than you might think, because· something like—I don't say *exactly* like—the powers involved in the self-healing of the human body should be looked for also in the changes of all other bodies.

But something much worse than that went wrong in their work: they focused on

- the principles governing things at rest, not on •the principles of change; i.e. on
- what things are produced *from*, not •*how* they are produced; i.e. on
- topics that they could talk about, not •ones that would lead to results.

The vulgar classification of ·kinds of· motion that we find in the accepted system of natural philosophy is no good—I mean the classification into

- generation,
- corruption,
- growth,
- diminution,
- alteration, and
- motion.

Here is what they mean. If a body is moved from one place to another without changing in any other way, this is •motion; if a body changes qualitatively while continuing to belong to the same species and not changing its place, this is •alteration; if a change occurs through which the mass and quantity of the body don't remain the same, this is •growth or •diminution; if a body is changed so much that it changes substantially and comes to belong to a different species, this is •generation or •corruption. But all this is merely layman's stuff, which doesn't go at all deeply into nature; for these are only *measures* of motion. . . .and not *kinds* of motion. They [= the notions involved in the classification into generation, corruption etc.] signify that the motion went this way or that, but not *how* it happened or what *caused* it. They tell us nothing about the appetites of bodies [= 'what bodies are naturally disposed to do'] or about what their parts are up to. They come into play only when the motion in question makes the thing grossly and obviously different from how it was. Even when ·scientists who rely on the above classificatory system· do want to indicate something concerning the *causes* of motion, and to classify motions on that basis, they *very* lazily bring in the ·Aristotelian· distinction between 'natural' motion and 'violent' motion, a distinction that comes entirely from vulgar ways of thinking. In fact, 'violent'

motion is natural motion that is called ‘violent’ because it involves an external cause working (naturally!) in a different way from how it was working previously.

[Bacon himself sometimes describes a movement as *violens*, but this is meant quite casually and not as a concept belonging to basic physics. These innocent occurrences of *violens* will be translated as ‘forceful’.]

Let us set all this aside, and consider such observations as that bodies have an appetite for

> mutual contact, so that separations can’t occur that would break up the unity of nature and allow a vacuum to be made;

or for

> resuming their natural dimensions. . . ., so that if they are compressed within or extended beyond those limits they immediately try to recover themselves and regain their previous size;

or for

> gathering together with masses of their own kind—e.g. dense bodies ·moving· towards the earth, and light and rare bodies towards the dome of the sky.

These and their like are truly *physical* kinds of motion; and comparison of them with the others that I mentioned makes clear that the others are entirely *logical* and *scholastic*.

An equally bad feature of their philosophies and their ways of thinking is that all their work goes into investigating and theorizing about the

- fundamental· principles of things. . . .—so they keep moving through higher and higher levels of abstraction until they come to *formless potential matter*—and
- the ultimate parts of nature—so they keep cutting up nature more and more finely until they come to *atoms*, which are too small to contribute anything to human welfare—

whereas everything that is useful, everything that can be worked with, lies between ·those two extremes·.

67. The intellect should be warned against the intemperate way in which systems of philosophy deal with the giving or withholding of assent, because intemperance of this kind seems to establish idols and somehow prolong their life, leaving no way open to reach and dislodge them.

There are two kinds of excess: •the excess of those who are quick to come to conclusions, and make sciences dogmatic and lordly; and •the excess of those who deny that we can know anything, and so lead us into an endlessly *wandering* kind of research. The •former of these subdues the intellect, the •latter deprives it of energy. The philosophy of Aristotle ·is of the former kind·. Having destroyed all the other philosophies in argumentative battle. . . . Aristotle laid down the law about everything, and then proceeded to raise new questions of his own and to dispose of them likewise, so that everything would be certain and settled—a way of going about things that his followers still respect and practice.

The ·Old Academy·, the school of Plato, introduced acatalepsy—·the doctrine that nothing is capable of being understood·. At first it was meant as an ironical joke at the expense of the older sophists—Protagoras, Hippias, and the rest—whose greatest fear was to seem *not* to doubt something! But the New Academy made a dogma of acatalepsy, holding it as official doctrine. They did allow of some things to be followed as probable, though not to be accepted as true; and they said they didn't ·mean to· destroy all investigation; so their attitude was better than. . . .that of Pyrrho and his sceptics. (It was also better than undue freedom in making pronouncements.) Still, once the human mind has despaired of finding truth, it becomes less interested in everything; with the result that men are side-tracked into pleasant disputations and discourses, into *roaming*, rather than severely sticking to a single course of inquiry. But, as I said at the start and continue to urge, the human senses and intellect, weak as they are, should not be •deprived of their authority but •given help.

68. So much for the separate classes of idols and their trappings. We should solemnly and firmly resolve to deny and reject them all, cleansing our intellect by freeing it from them. Entering the kingdom of man, which is based on the sciences, is like entering the kingdom of heaven, which one can enter only as a little child.

Edited: The next post in the sequence, Book 1: 69-92 (13 Causes of Bad Science), will be posted Thursday, October 3rd at latest by 6:00pm PDT.

13 Causes of Bad Science (Novum Organum Book 1: 69-92)

This is the sixth post in the Novum Organum sequence. For context, see the sequence introduction.

We have used Francis Bacon's Novum Organum in the version presented at www.earlymoderntexts.com. Translated by and copyright to Jonathan Bennett. Prepared for LessWrong by Ruby.

Ruby's Reading Guide

> Novum Organum is organized as two books each containing numbered "aphorisms." These vary in length from three lines to sixteen pages. Bracketed titles of posts in this sequence, e.g. *Idols of the Mind Pt. 1*, are my own and do not appear in the original.
>
> While the translator, Bennett, encloses his editorial remarks in a single pair of [brackets], I have enclosed mine in a [[double pair of brackets]].

Bennett's Reading Guide

> [Brackets] enclose editorial explanations. Small ·dots· enclose material that has been added, but can be read as though it were part of the original text. Occasional •bullets, and also indenting of passages that are not quotations, are meant as aids to grasping the structure of a sentence or a thought. Every four-point ellipsis . . . . indicates the omission of a brief passage that seems to present more difficulty than it is worth. Longer omissions are reported between brackets in normal-sized type.

Aphorism Concerning the Interpretation of Nature: Book 1: 69–92

by Francis Bacon

[[Bacon continues on from the discussion of Idols of the Mind. *Demonstration* might be interpreted simply as *experiment*, but is likely closer to meaning of Aristotle's demonstrations: a *scientific deduction* where one moves from premises in which one has high confidence to new conclusions.]]

69. But the idols have defences and strongholds, namely defective demonstrations; and the demonstrations we have in dialectics do little except make •the world a slave to •human thought, and make human thought a slave to •words. Demonstrations are indeed incipient philosophies and sciences: how good or bad a demonstration is determines how good or bad will be the system of philosophy and the thoughts that follow it. Now the demonstrations that we use in our whole process of getting from the •senses and •things to •axioms and conclusions are defective and inappropriate. This process has four parts, with a fault in each of them. **(1)** The impressions of the senses itself are faulty, for the senses omit things and deceive us. Their omissions should be made up for, and their deceptions corrected. **(2)** Notion are abstracted *badly* from the impressions of the senses, and are vague and confused where they should be definite and clearly bounded.

(3) Induction goes wrong when it infers scientific principles by simple enumeration, and doesn't, as it should, take account of the exceptions and distinctions that nature is entitled to. **(4)** The method of discovery and proof in which you *first* state the most general principles and *then* bring the intermediate axioms into the story, 'proving' them from the general principles, is the mother of errors and a disaster for all the sciences. At this stage I merely touch on these matters. I'll discuss them more fully when, after performing these cleansings and purgings of the mind, I come to present the true way of interpreting nature.

70. The procedure that starts with experience and *sticks close to it* is the best demonstration by far. A procedure that involves transferring a result to other cases that are judged to be similar is defective unless the transfer is made by a sound and orderly process. The way men conduct experiments these days is blind and stupid. Wandering and rambling with no settled course and only such 'plans' as events force on them, they cast about and touch on many matters, but don't get far with them. Sometimes they are eager, sometimes distracted; and they always find that some further question arises. They usually conduct their experiments casually, as though this were just a game; they slightly vary experiments that are already known; and if an experiment doesn't come off, they grow weary and give up the attempt. And even if they worked harder at their experiments, applying themselves more seriously and steadfastly, ·they *still* wouldn't get far, because· they work away at some *one experiment*, as Gilbert did with the magnet and the chemists do with gold. That is a way of proceeding that is as unskilful as it is feeble. For no-one successfully investigates the nature of a thing taken on its own; the inquiry needs to be enlarged so as to become more general.

And even when they try to draw some science, some doctrines, from their experiments, they usually turn aside and rashly embark on premature questions of practical application; not only for the practical benefits of such applications, but also because they want to *do* things that will •assure them that it will be worth their while to go on, and •show themselves in a good light to the world and so •raise the credit of the project they are engaged in. They are behaving like Atalanta ·in the legend from ancient Greece·: she turned aside to chase a golden ball, interrupting her running of the race and letting victory slip through her fingers. But in using the true course of experience to carry out new works, we should model our behaviour on the divine wisdom and order. On the first day of creation God created light and nothing else, devoting an entire day to a work in which no material substance was created. We should follow suit: with experience of any kind, we should first try to discover true causes and axioms, looking for •enlightening experiments rather than for •practically fruitful ones. For axioms don't *singly* prepare the way for practical applications, but *clusters of* rightly discovered and established axioms do so, bringing in their wake streams—*crowds*!—of practical works. The paths of experience are just as rocky and jammed as the paths of judgment, and I'll discuss that later. I have mentioned ordinary experimental work at this stage only in its role as a bad kind of demonstration. But considerations of order now demand that I take up next ·two linked topics·: •the signs or omens (mentioned a little way back) that current systems of philosophy and of thought are in a bad condition; and •the causes of ·this badness, which· seems at first so strange and incredible. When you have seen •the signs you will be more likely to agree ·with me about the badness·; and my explanation of •its causes will make it seem less strange. These two together will greatly help to render the process of wiping the idols from the intellect easier and smoother. ·My discussion of •the signs will run to the end of **77**, and •the causes will run from there to the middle of **92**·.

[In the next seven sections, the Latin *signa* will be translated sometimes as 'signs' and sometimes as 'omens'.]

71. The sciences that we have come mostly from the Greeks. For the additions by Roman, Arabic and later writers are neither plentiful nor important, and such as they are they have been built on the foundation of Greek discoveries. Now, the wisdom of the Greeks was that of teachers of rhetoric, and it spawned disputations, which made it the worst kind of inquiry for finding the truth. Those who wanted to be thought of as philosophers contemptuously gave the label 'sophists' to the ancient rhetoricians Gorgias, Protagoras, Hippias and Polus; but really the label fits the whole lot of them: Plato, Aristotle, Zeno, Epicurus, Theophrastus, and their successors Chrysippus, Carneades and so on. There was this just difference: •the rhetoricians were wandering and mercenary, going from town to town, offering their wisdom for sale, and taking a price for it; whereas •the others were more ceremonial and 'proper'—men who had settled homes, and who opened schools and taught their philosophy without charging for it. But although the two groups of philosophers were in other ways unalike, they had one thing in common: both lots were teachers of rhetoric; both turned everything into a matter for disputations, and created sects that they defended against heresies. They turned it all into •'the talk of idle old men to ignorant youths' (Dionysius's jibe against Plato, a not unfair one!). But the earlier of the Greek philosophers—Empedocles, Anaxagoras, Leucippus, Democritus, Parmenides, Heraclitus, Xenophanes, Philolaus and so on (omitting Pythagoras because he was a mystic)—didn't open schools, as far as we know. What they did was to *apply themselves to the discovery of truth*, doing this

- more quietly, severely and simply—that is, with less affectation and parade—

than the others did. And in my judgment they also performed

- more successfully,

·or would have done so· if it weren't for the fact that their works were in the course of time obscured by less substantial people who offered more of what suits and pleases the capacity and tastes of the vulgar. Time is like a river, bringing lightweight floating stuff down to us and letting heavier and solider things sink. Still, not even they—·Empedocles and the rest·—were entirely free of the Greek fault: they leaned too far in the direction of ambition and vanity, founding sects and aiming for popular applause. The inquiry after •truth has no chance of succeeding when it veers off after •trifles of this kind. And I ought to mention the judgment, or rather the prediction, that an Egyptian priest made about the Greeks, namely that 'they are always *boys*, with no •long-established knowledge and no •knowledge of ancient times' [neater in Latin: •*antiquitatem scientiae* and •*scientiam antiquitatis*]. Assuredly they were like boys in their readiness to chatter, and in their inability to father anything—for their wisdom is full of words but sterile in works. So when we consider the currently accepted philosophy in the light of its place of origin and its family tree, the omens are not good!

72. And the omens provided by the character of the time and age aren't much better than the ones from the character of the place and the nation. For knowledge at that period concerned only a short stretch of time and a small part of the world, and that's the worst state to be in, especially for those who base everything on experience. For the preceding thousand years they had no *history* worthy of the name, but only fables and verbal traditions. And they knew only a small portion of the regions and districts of the world; they indiscriminately called everyone to the north of them 'Scythians'. and those to the west 'Celts'; they knew nothing of Africa beyond the nearest part of Ethiopia, or of Asia beyond the Ganges. They knew even less about the provinces of the New World. . . .and declared to be uninhabitable a multitude of climates and zones where actually countless nations live and breathe. . . . (Contrast that with the present day: we know many parts of the New World as well as the whole of the Old World, and our stock of experience has grown infinitely.) So if like astrologers we take omens ·for contemporary systems of philosophy· from the facts about *when* they were born, we can't predict anything great for them.

73. Of all the signs ·we can have of the value of a field of endeavour·, none are more certain or more conspicuous than those based on the *upshots* ·of the endeavour·. For upshots and useful practical applications are like sponsors and guarantors of the truth of philosophies. [Throughout this work, 'philosophies' include 'sciences'.] Now, from all those systems of the Greeks and the particular sciences derived from them, you can hardly name a single experiment that •points the way to some improvement in the condition of man, and that •really does come from the speculations and theories of philosophy. Hardly one, after all those years! And Celsus honestly and sensibly admits as much, when he tells us that •the practical part of medicine was discovered first, and that *then* •men philosophized about it and hunted for and assigned causes; rather than the reverse process in which •philosophy and the knowledge of causes led to •the discovery and development of the practical part. So it isn't strange that among the Egyptians, who rewarded inventors with divine honours and sacred rites, there were more images of the lower animals than of men; for the lower animals have made many discoveries through their natural instincts, whereas men have given birth to few or none through their discussions and rational inferences.

The work of chemists has produced a little, but only •accidentally and in passing or else •by varying previous experiments (just as a mechanic might do!), and not by any skill or any theory. For the theory that they have devised does more to confuse the experiments than to help them. And the people who have busied themselves with so-called 'natural magic' have come up with nothing but a few trifling and apparently faked results. In religion we are warned to *show our faith by our works*; the same rule applies in philosophy, where a system should be judged by its fruits, and pronounced frivolous if it turns out to be barren, especially when it bears the thorns and thistles of dispute and contention rather than the fruits of grape and olive.

74. The growth and progress of systems and sciences provides signs ·as to their value·. Something that is grounded in nature grows and increases, while what is based on opinion *alters* but doesn't *grow*. If those doctrines ·of the ancient Greeks· hadn't been so utterly like a plant torn up by its roots, and had remained attached to and nourished by the womb of nature, the state of affairs that we have seen to obtain for two thousand years—namely

the sciences stayed in the place where they began, hardly changing, not getting any additions worth mentioning, thriving best in the hands of their first founders and declining from then on

—would never have come about. This is the opposite of what happens with the mechanical arts, which are based on nature and the light of experience: they (as long as they find favour with people) continually thrive and grow, having a special kind of *spirit* in them, so that they are at first rough and ready, then manageable, from then onwards made smoothly convenient by use—and *always growing*.

75. Admissions made by the very authorities whom men now follow constitute another sign ·that today's sciences are in trouble·—if it is all right to apply the label 'sign' to what is really testimony, indeed the most reliable of all testimony. Even those who so confidently pronounce on everything do intermittently pull themselves together and complain of the subtlety of nature, the obscurity of things, and the weakness of the human mind. ·These complaints are not just a sign of trouble in the sciences; they are worded in such a way that they cause further harm·. If these people merely *complained*, some cowards might be deterred from searching further, while others with livelier minds and a more hopeful spirit might be spurred and incited to go on. But the complainers don't merely speak for themselves: if something is beyond their knowledge or reach, and of their master's, they declare it to be beyond the bounds of possibility, something that can't be known or done; so that their lofty ill-nature turns the weakness of their own 'discoveries' into a libel against nature herself and a source of despair for the rest of the world. •Thus the school of the New Academy, which doomed men to everlasting darkness by maintaining as a matter of doctrine that nothing at all could be known. •Thus the opinion that men can't possibly discover the *forms*, i.e. the real differentiae of things ·that put things into different species· (really they are laws of pure action [see note here]). •Thus also certain opinions in the field of action and operation, e.g. that the heat of the sun is quite different in kind from the heat of fire, so that no-one will think that the operations of fire could produce anything like the works of nature ·that are produced by the sun·. •That's the source of the view that. . .

Latin: . . . *compositionem tantum opus hominis, mistionem vero opus solius naturae esse*

literal meaning: . . . men are capable only of composition, and mixing has to be the work of nature

intended meaning? . . . men are capable only of assembling things into physical mixtures (e.g. salt and pepper), and the subtler kind of combination involved in something's being gold or water or salt or the like must be the work of nature

—lest men should hope to develop techniques for generating or transforming natural bodies, ·e.g. creating water or turning lead into gold·. ·I point out· this sign ·of second-rateness· to warn you not to let your work and your career get mixed up with dogmas that are not merely discouraging but are *dedicated* to discouragement.

76. Here is another sign ·of something's being wrong· that I oughtn't to pass over: the fact that formerly there existed among philosophers such great disagreement, and such differences between one school and another. This shows well enough that the road from the senses to the intellect was not well defended ·with walls along each side·, when the same raw material for philosophy (namely the nature of things) has been taken over and used to construct so many wandering pathways of error. These days, most of the disagreements and differences of opinion on first principles and entire ·philosophical· systems have been extinguished; but there are still endless questions and disputes concerning some *parts* of philosophy, which makes it clear that there is nothing certain or sound in the systems themselves or in the modes of demonstration ·that they employ·.

77. Some men think this:

> There ·*is* great agreement in philosophy these days, because there is· widespread agreement in assenting to the philosophy of Aristotle; as witness the fact that once it was published the systems of earlier philosophers fell into disuse and withered away, while in the times that followed nothing better was found. Thus, it seems to have been so well laid out and established that it has drawn both ages—·ancient and modern·—to itself.

[[Philosophy here likely means *philosophy and science* unlike in modern usage where philosophy has been separated from science.]]

I start my reply to this by remarking that the general opinion that the old systems stopped being used or consulted when Aristotle's works were published is *false*. In fact, long afterwards—even down to the times of Cicero and later centuries—the works of the old philosophers still remained. But in the times that followed, when the flood of barbarians pouring into the Roman empire made a shipwreck of human learning, *then* the systems of Aristotle and Plato, like planks of lighter and less solid material, floated on the waves of time and were preserved. As for the point about agreed assent: if you look into this more carefully you'll see that the view I am discussing is wrong about that too. For genuine *agreement* is based on people's having duly examined some matter and reached, freely ·and independently·, the same opinion about it. But the great majority of those who have assented to the philosophy of Aristotle have delivered themselves over to it on the strength of the prejudices and the authority of others; so that this is less a case of *agreement* than of *moving together as a crowd*. But even if it had been a real and widespread agreement, that is so far from being •solid confirmation of the truth ·of Aristotle's philosophy· that it actually creates a •strong presumption of its falsity. For in intellectual matters the *worst* of all auguries is ·general· consent, except in theology (and in politics, where there is a right to vote!). This is because of something I have already mentioned: that

nothing pleases the multitude unless it appeals to the imagination or ties the intellect up with knots made from the notions of the vulgar. Something that Phocion said about morals can very well be re-applied to intellectual matters, namely that if the multitude accept ·what you say· and are united in their applause, you should immediately check yourself to see where you have gone wrong. So *this* sign is one of the *least* favourable.

That brings me to the end of what I have to say to make my point that the signs of health and truth in the currently accepted philosophical systems and sciences are *not good*, whether they be drawn from their origins (**71–2**), their upshots (**73**), their progress (**74**), the admissions of their founders (**75**), or agreed acceptance (**77**).

78. I now come to the *causes* of these errors—so many of them, and such bad ones!—that have continued on through all those centuries. ·My discussion of thirteen of them will run on through **92**·. You may have been wondering how the points I have made could have escaped men's notice until now; my account of the causes should stop you wondering about that. When you understand the causes, you may have something else to be surprised by, namely the fact that someone *has* now seen through the errors, thought about them, and come up with my points against them. As for that, I see it as coming from my good luck rather than from my superior talents; it's not that I am so clever, but rather that I was born at the right time.

(1) The first point ·about how long the errors went undetected· is this: If you look hard at 'all those centuries' you'll see that they shrink into something quite small. We have memories and records of twenty-five, and of those you can hardly pick out *six* that were fertile in the sciences or favourable to their development. (There are wastelands and deserts in times just as in regions of the earth!) We can properly count only *three* periods when learning flourished, and they lasted barely *two* centuries each: that of •the Greeks, the second of •the Romans, and the last among us—•the nations of western Europe. The intervening ages of the world were not flourishing or fertile for the growth of knowledge. (Don't cite the Arabs or the schoolmen ·as counter-examples to that·; for they spent the intervening times not •adding to the weightiness of the sciences but crushing them with the weight of their books!) So there is one cause for the lack of progress in the sciences, namely the brevity of the periods that can properly be said to have been favourable to them.

79. (2) Here is a second cause, and one of great all-around importance: Precisely at the times when human intelligence and learning have flourished most, or indeed flourished at all, men *didn't* work at natural philosophy [here = 'natural science']. Yet it should have been regarded as the great mother of the sciences; because all arts and all sciences, though they may be polished and shaped and made fit for use, won't *grow* at all if they are torn from this root ·of natural philosophy·. It is clear that after the Christian religion was generally accepted and grew strong, the vast majority of the best minds applied themselves to theology, that this offered the best promise of reward and the most abundant research support of all kinds, and that this focus on theology was the chief occupation ·of able people· in western Europe during the **third** period ·of the three I have named·—all the more so because at about the same time literacy began to be more widespread and religious controversies sprang up. During the Roman period—the **second** of my trio—philosophers mostly worked on and thought about moral philosophy, which was to the pagans what theology is to us. Also, in those times the best intelligences usually devoted themselves to public affairs, because the sheer size of the Roman empire required the services of a great many people. And—·moving back to the **first** of my trio·—there was only a tiny portion of time when natural philosophy was seen to flourish among the Greeks; for in earlier times all except Thales of the so-called 'seven wise men' applied themselves to

morals and politics; and in later times, when Socrates had drawn philosophy from heaven down to earth, moral philosophy became more fashionable than ever and diverted men's minds from the philosophy of nature.

And right at the time when inquiries into nature *were* carried on energetically, they were spoiled and made useless by controversies and the ambitious display of new opinions. During those three periods, then, natural philosophy was largely neglected or impeded, so it's no wonder that men made so little progress with something that they weren't attending to.

[This is the first of eleven remarks along the lines of 'No wonder science hasn't progressed, given the fact that. . . '—one for each of Bacon's causes of non-progress except the first and last.]

80. (3) I would add that especially in recent times natural philosophy, even among those who *have* attended to it, has scarcely ever had anyone's complete and full-time attention (except perhaps a monk studying in his cell, or an aristocrat burning the midnight oil in his country house); it has usually been treated as merely a bridge leading to something else. And so ·natural philosophy·, that great mother of the sciences, has been subjected to the astonishing indignity of being degraded to the role of a servant, having to *help* medicine or mathematics in their affairs, and to give the immature minds of teen-agers a first dip in a sort of dye, to make them better able to absorb some other dye later on. Meanwhile don't look for much progress in the sciences—especially in their practical part—unless natural philosophy is applied to particular sciences, and particular sciences are applied back again to natural philosophy. It is because this hasn't been done that many of the sciences have no *depth* and merely glide over the surface of things. What sciences? Well, astronomy, optics, music, many of the mechanical arts, even medicine itself—and, more surprisingly, moral and political philosophy and the logical sciences. Because once these particular sciences have become widespread and established, they are no longer nourished by natural philosophy, which could have given them fresh strength and growth drawn from the well-springs—from true thoughts about

- motions, rays, sounds and textures, and
- microstructures of bodies [Bacon's many uses of the word *schematismus* show that for him a body's *schematismus* is its fine-grained structure. This version will always use 'microstructure', but be aware that Bacon doesn't use a word with the prefix 'micro'.], and
- feelings and intellectual processes.

So it's not at all strange that the sciences don't grow, given that they have been cut off from their roots.

81. (4) Another great and powerful cause why the sciences haven't progressed much is this: You can't run a race properly when the finishing-post hasn't been properly positioned and fixed in place. Now the true and lawful finishing-post of the sciences is just *new discoveries and powers in the service of human life*. But the great majority of the mob ·of supposed scientists· have no feeling for this, and are merely hired lecturers. Well, occasionally some ambitious practitioner who is abler than most spends his own resources on some new invention; but most men are so far from aiming to *add* anything to the arts and sciences that they don't even *attend to* what's already there or *take* from it anything that they can't use in their lectures or use in the pursuit of money or fame or the like. And when one of that multitude *does* pay court to science with honest affection and for her own sake, even then it turns out that what

attracts him is not the stern and unbending search for truth so much as the richness of the array of thoughts and doctrines. And if there should happen to be one who pursues the truth in earnest, even he will be going after •truths that will satisfy his intellect by explaining the causes of things long since discovered, and not •truths that hold promise of new practical applications or •the new light of axioms. If the •end of the sciences hasn't yet been placed properly, it isn't strange that men have gone wrong concerning the •means.

82. (5) So men have mislocated the end and finishing-post of the sciences; but even if they hadn't, their *route* to it is completely wrong and impassable. When you think about it carefully, it is amazing that •no mortal has *cared* enough or *thought hard* enough to lay out a securely walled road leading to the human intellect directly from the senses and experiment, and that •everything has been left either to the mists of tradition, or the whirl and eddy of argument, or the waves and mazes of random and fragmentary experience. Think about this soberly and carefully: What route *have* men customarily travelled in investigating and discovering things? No doubt what you will first come up with is a very simple and naive discovery procedure, the most usual one, namely this:

> A man is bracing himself to make a discovery about something: first he seeks out and surveys **everything that has been said about it by others**; then he starts to think for himself; shaking up his mind and, as it were, praying to it to give him oracular pronouncements

—a 'method' that has no foundation at all, rests only on opinions, and goes where they go. Another man may perhaps call on **dialectics** to make his discovery for him, but the discoveries that dialectics is good for are irrelevant to what we are discussing —there's nothing in common except the word 'discovery'.

[Regarding the passage between *asterisks*: Bacon writes of 'arts' but doesn't give examples (medicine and ship-building). This text also expands his in other ways that ·dots· can't easily indicate.]

*Arts such as medicine and ship-building are made up of principles and axioms, and dialectics doesn't discover these; all it can 'discover', given that you have the principles and axioms from some other source, is what else is consistent with them. If we try to insist on more than that, demanding that dialectics tell us what the •principles and axioms are, we all know that it will fling the demand back in our faces: 'For •*them* you must trust the art in question. For the foundations of medicine, for example, don't ask *dialectics*, ask *medicine*!'* ·Setting aside the opinions of others, and dialectics·, there remains **simple experience**—which we call 'experiment' if we were trying to produce it, and 'chance' if we weren't. But such experience is no better than a broom with loose bristles, as the saying is—·those who steer by it are· like men in the dark, patting the walls as they go along hoping to find their way, when they'd have done much better to wait for daylight, or light a candle, and *then* set off. But **experience managed in the right •order** first lights the candle and then uses it to show the way. It starts with experience that is ordered and classified, not jumbled or erratic; from that it derives axioms, and from established axioms it moves on to new experiments; just as God proceeded in an •orderly way when he worked on matter. So don't be surprised that science hasn't yet reached the end of its journey, seeing that men have gone altogether astray, either abandoning experience entirely, or getting lost in it and wandering around as in a maze. Whereas a rightly ordered method leads by an unbroken route through the thickets of experience to the open ground of axioms.

83. This trouble ·concerning not-finding-the-way· has been greatly increased by an old and *harmful* opinion or fancy, namely the self-important view that it is beneath the dignity of the human mind to be closely involved with experiments on particular material things given through the senses— especially as they are

- hard work to investigate,
- trivial to think about,
- nasty to report on,
- not suitable things for a gentleman to perform,
- infinite in number, and
- full of extremely small-scale details.

So that it has finally come to this: the true way is not merely departed from but blocked off. It's not that experience has been abandoned or badly handled; rather, it has been fastidiously kept at arm's length.

84. (6) Men have been kept back from making progress in the sciences, as though by a magic spell, by •their reverence for antiquity, by •the authority of men of high standing in philosophy, and then by •the general acceptance ·of certain propositions·. I have spoken of the last of these ·in **77**· above.

As for 'antiquity', the opinion that men have about it is a lazy one that does violence to the meaning of the word. For really what is *antique* is •the world in its old age, that is the world *now*; and •the earlier age of the world when the ancients lived, though in relation to us it was the elder, in relation to the world it was the younger. We expect •an old man to know more about the human condition than •a young man does, and to make more mature judgments about it, because of his experience and the number and variety of things he has seen, heard and thought about. In the same way, more could be fairly expected from •our age (if only we knew and chose to employ its strength) than from •ancient times, because ours is a more advanced age of the world, and has accumulated countless experiments and observations.

It is also relevant that through long voyages many things in nature will be discovered that may let in new light on philosophy (and such voyages will be increasingly frequent in our age). And given that the regions of the •material domain—i.e. of the earth, the sea and the stars—have been opened up and brought to light, it would surely be disgraceful if the •intellectual domain remained shut up within the narrow limits of old discoveries.

And with regard to authority: there is something feeble about granting so much to •authors while denying •time its rights—time, which is the author of authors, or rather of all authority. For the saying is 'Truth is the daughter of time', not '. . . the daughter of authority'!

We shouldn't be surprised, then, when we find that the enchantments of •antiquity and •authority and •general agreement have tied up men's powers—as though putting them under a spell—making them unable to rub shoulders with •*things themselves*.

85. (7) What brings man's work to a halt in face of the discoveries that have already been made is not merely his admiration for antiquity, authority and general agreement, but also his admiration for the long-time achievements of the human race. When you look at the variety and beauty of the devices that the mechanical arts have assembled for men's use, you'll surely be more inclined to admire man's wealth than to have any sense of his poverty! You won't take into account the fact that

> the original human observations and natural processes (which are the soul and first mover of all that variety)

are not many and didn't have to be dug deeply for; and that apart from them it has been merely a matter of

> patience, and the orderly and precise movements of hands and tools.

For example, it certainly takes precise and accurate work to make a clock, whose wheels seem to imitate the heavenly bodies and, in their alternating and orderly motion, to imitate the pulse of animals; but ·there isn't much scientific content in this, because the entire mechanism· depends on only a couple of axioms of nature.

[Bacon next writes about 'the refinement of the liberal arts' and of the 'art' that goes into 'the mechanical preparation of natural substances', and lists the achievements in astronomy, music, language, the alphabet ('still not used in China'), the making of beer, wine and bread, and so on. His point is that these achievements took centuries of tinkering, and that they involve very little in the way of genuinely scientific knowledge. So they—like the clock—make it less appropriate to wonder at how *much* we know than to wonder at how *little*. Then:]

If you turn from the workshop to the library, and wonder at the immense variety of books you see there, just look carefully into their contents and your amazement will be *flipped*: having seen their endless repetitions, and seen how men are always saying and doing what has been said and done before, you'll pass from •admiration at the variety to •astonishment at the poverty and scantiness of the subjects that have so far possessed the minds of men.

[Next Bacon comments derisively on the intellectual poverty of alchemy. Then:] The students of natural magic, who explain everything by 'sympathies' and 'antipathies', have in their lazy conjectures credited substances with having wonderful powers and operations. If they have ever they produced any results, they have been more productive of astonishment than of anything useful. [Followed by a slap at 'superstitious magic'; Bacon expresses some embarrassment at even mentioning this, as he does with alchemy. Finally:] It isn't surprising that the belief that one has a great deal has been a cause of our having very little.

86. (8) Furthermore, men's feeble and almost childish admiration for doctrines and arts has been increased by the tricks and devices of those who have practised and taught the sciences. For they produce them with so much fuss and flourish, putting them before the world all dressed up and masked ·and seemingly ready to go·, as though they were wholly complete and finished. Just look at the structure and the classifications they bring with them! They seem to cover everything that could come up in that subject, and to the minds of the vulgar they present the form and plan of a perfected science; but really the classificatory units are little more than empty bookshelves. The earliest seekers after truth did better than this. Their thoughts about things resulted in knowledge that they want to set down for later use, and they did this in *aphorisms*—i.e. short unconnected sentences, not linked by any method—and didn't pretend or profess to cover the entire art. But given the way things are these days, it's not surprising that men don't try to make further progress in matters that have been passed down to them as long since perfect and complete.

87. (9) The •ancient systems have also gained considerably in their reputation and credit from the empty-headed foolishness of those who have propounded •new ones, especially in the area of applied science. There has been no shortage of talkers and

dreamers who—partly believing what they say and partly not—have loaded mankind with promises, offering the means to

- prolong life,
- slow down the aging process,
- lessen pain,
- repair natural defects,. . . .
- control and arouse affections,
- sharpen and heighten the intellectual faculties,
- turn substances into other substances (·e.g. lead into gold·),
- make things move, or move faster, at will,
- make changes in the air,
- arrange for influence from the stars,
- prophesy the future,
- make things visible from a long way off,
- reveal things that are hidden,

and many more. With regard to these 'benefactors' it wouldn't be unfair to say that •their absurdities differ as much from •true arts (in the eyes of the philosopher) as •the exploits of Julius Caesar or Alexander the Great differ from •those of ·such fictional characters as· Amadis of Gaul or the Knights of the Round Table. . . . It isn't surprising that prejudice is raised against new propositions, especially ones that are said to have practical implications, because of those impostors who have tried something similar. . . .

[[Bacon seems to speaking of idea inoculation here where people have been inoculated against new sciences because of the charlatans promising things they fail to deliver.]]

88. (10) Far more harm has been done to knowledge by pettiness, and the smallness and triviality of the tasks that men have tackled. It is made worse by the fact that this pettiness comes with a certain air of arrogance and superiority. A now-familiar general device that is found in all the arts is this: the author blames *nature* for any weakness in his art, declaring—on the authority of his art!—that whatever his art can't achieve is intrinsically impossible. ['Art' refers to any human activity that involves techniques and requires skills.] If arts are to be their own judges, then clearly none will be found guilty! Moreover, the philosophy that is now in play hugs to itself certain tenets whose purpose. . . .is to persuade men that we can't expect art or human labour to come up with any results that are hard to get, requiring that nature be commanded and subdued. The doctrine that the sun's heat and fire's heat differ in kind is an example of this, and another is the doctrine about mixture—both mentioned earlier, ·in **75**·. If you think about it carefully you'll see that all this involves a wrong limiting of human power; it tends—and is *meant to* tend—to produce an unnatural despair; and this not only messes up the auguries that might give hope but also cuts the sinews and spurs of industry, and loads the dice against experience itself. And all for the sake of having us think that their art has been completed, and for the miserable 'triumph' of getting us to believe that whatever *hasn't yet* been discovered and understood *can't ever* be discovered or understood.

And when someone *does* get in touch with reality and try to discover something new, he will confine himself to investigating and working out some *one* topic, such as

- the nature of the magnet,
- the tides,

- mapping the heavens,

and things like that, which seem to be somewhat isolated from everything else and have hitherto been tackled without much success; whereas really it is an ignorant mistake to study something in isolation. Why? Because a nature that seems to be •latent and hidden in some things is •obvious and (as it were) palpable in others, so that people puzzle over it in •the former while nobody even notices it in •the latter. Consider the *holding-together* ·of material things·. Wood and stones hold together, but people pay no attention to that fact, merely saying of wood and stone that 'they are *solid*' and giving no further thought to why they don't fall apart, breaking up their continuity; while with water-bubbles—in which a sort of hemispherical skin is formed, fending off for a moment the breaking up of the continuity—the holding together seems to be a subtle matter.

In fact, what in some things is regarded as special to them ·and not present in the rest of nature· also occurs elsewhere in an obvious and well-known form, but it won't be recognized *there* as long as the experiments and thoughts of men are engaged only on the former, ·i.e. on the less obvious and supposedly 'special' cases·. But generally speaking, in mechanics all that is needed for someone to pass off an old result as something new is •to refine or embellish it, •to combine it with some others, •to make it handier for practical application, •to produce the result on a larger or a smaller scale than had been done before, or the like.

So it is no wonder that no important discoveries worthy of mankind have been brought to light, when men have been satisfied—indeed *pleased*—with such trifling and puerile tasks, and have even fancied that in them they were trying for something great, if not achieving it.

89. (11) Bear in mind also that in every period natural philosophy has had a troublesome and recalcitrant adversary in superstition and blind religious extremism. Among the Greeks those who first proposed *natural* causes for lightning and for storms were condemned for disrespect towards the gods. And some of the fathers of the early Christian church were not much milder in their attitude to those who, on most convincing grounds that no sane person would question today, maintained that the earth is round and thus that the antipodes exist.

Even today it is harder and more dangerous ·than it ought to be· to talk about nature, because of the procedures of the theological schoolmen. They regularized theology as much as they could, and worked it into the shape of an art [here = 'academic discipline'], and then incorporated into the body of religion more of Aristotle's contentious and thorny philosophy than would properly fit there. The same result is apt to arise, though in a different way, from the theories of those who have been so bold as to infer the truth of the Christian religion from the principles of •philosophers, and to confirm it by •their authority. They have solemnly and ceremonially celebrated this union of the senses with faith as a lawful marriage, entertaining [*permulcentes*] men's minds with a pleasing variety things to think about but also mixing [*permiscentes*] the human with the divine in an unseemly fashion. In such mixtures of theology with philosophy only the accepted doctrines of philosophy are included, while •new ones—which may be changes for the better—are driven off and wiped out.

Lastly, you will find that some ignorant divines close off access to any philosophy, however 'purified' it may be. •Some are feebly afraid that a deeper search into nature would take one beyond the limits of what is proper; and they take what is said in the Scriptures against those who pry into

- *sacred* mysteries,

wrenching it away from there and transferring it to

- the hidden things of n*ature,*

which are not fenced off by any prohibition ·in the Bible·. •Other divines are more complex and thoughtful: they think that if middle causes [see note in **65**] aren't known then it will be easier to explain *everything* in terms of God's hand and rod; and they think that this is greatly in the interests of religion, whereas really it's nothing but *trying to gratify God by a lie*. •Others are led by past examples to fear that movements and changes in philosophy will end in attacks on religion. And •others again—·bringing us to the end of my list·—seem to be afraid that if nature is investigated something may be found to subvert religion or at least to shake its authority, especially with the unlearned. But these two last fears strike me as having come from thinking at the level of the lower animals, ·like a dog cowering in fear when it hears an unfamiliar noise·; it's as though these men in their heart of hearts weren't sure of the strength of religion and of faith's domination of the senses, and were therefore scared that the investigation of truth in nature might be dangerous to them. But in point of fact natural philosophy is second only to the Bible as the best antidote to superstition and the most approved nourishment for faith. So natural philosophy deserves its place as religion's most faithful handmaid: religion displays God's •will, while natural philosophy displays his •power. . . . ·Summing up·: it isn't surprising that •natural philosophy is stunted in its growth when religion, the thing that has most power over men's minds, has been pulled into the fight *against* •it by the stupidity and incautious zeal of certain people.

90. (12) Moving on now: in the customs and institutions of schools, academies, colleges, and similar bodies whose role is to house learned men and to develop learning, *everything* turns out to work against the progress of the sciences. Their lectures and tests are devised in such a way that it would be hard for anyone to think or speculate about anything out of the common rut. And if one or two have the courage to *judge freely*, they'll have to do it all by themselves with no help from the company of others. And if they can put up with that too, they will find that their hard work and breadth of mind are a considerable hindrance to their careers! For the studies of men in these places are confined—as it were *imprisoned*—in the writings of certain authors, and if anyone disagrees with them he is immediately accused of being a trouble-maker and a revolutionary. But ·this is all wrong, because· the situation of the •arts is quite different from that of the •state, and the coming of •new light ·in the arts· is not like the coming of •new events ·in the state·. In matters of state any change—even a change for the better—is under suspicion of making trouble, because politics rests on authority, consent, fame and opinion, not on demonstration. But arts and sciences should be like quarries, where the noise of new works and further advances is heard on every side. That is how things stand according to right reason, but it's not what actually happens; and the things I have reported in the administration and government of learning severely restrain the advancement of the sciences.

91. Indeed, even if that hostility ·towards new work· stopped, the growth of the sciences would still be held back by the fact that high aims and hard work in this field go unrewarded. For the *rewarding* of scientific achievement and the *performing* of it are not in the same hands. The growth of the sciences comes from high intelligence, while the prizes and rewards of them are in the hands of the common people, or of 'great' persons who are nearly all quite ignorant. Moreover, not only do scientific

advances bring no rewards or other benefits, they don't even get popular applause. For the common run of people aren't up to the task of understanding such matters, so that news about them is apt to be blown away by the gales of popular opinions. And it's not surprising that endeavours that are not honoured don't prosper.

92. (13) By far the greatest obstacle to the progress of science—to the launching of new projects and the opening up of new fields of inquiry—is that men despair and think things impossible. For in these matters it's the careful, serious people who have no confidence at all, and are taken up with such thoughts as that

- nature is dark,
- life is short,
- the senses are deceptive,
- judgment is weak,
- experiments are hard to do,

and the like. They think that •throughout the centuries the sciences have their ebbs and flows, sometimes growing and flourishing and at others withering and decaying, but that •a time will come when the sciences are in a state from which no further progress will be possible. ·And they evidently think that that time lies in the *very* near future·. So if anyone expects or undertakes to make further discoveries, they set this down to his immature irresponsibility. Such endeavours, they think, start well, become harder as they go on, and end in confusion. This is a way of thinking that sober intelligent men are likely to fall into, and we mustn't let *their* charms and attractions lead us to relax or mitigate our judgment ·of their line of thought·. We should carefully note what gleams of hope there are and what direction they come from; and—·changing the metaphor·—we should disregard the lighter breezes of hope but seriously and attentively follow the winds that seem to be steadier. We must also look to political prudence for advice, and to *take* the advice it gives; it is distrustful on principle, and takes a dim view of human affairs. So my topic here ·and to the end of **114**· is *hope*; for I don't trade in promises, and don't want to affect men's judgments by force or by trickery; rather, I want to lead them by the hand without coercion. The best way to inspire hope will be to bring men to *particulars*, especially ones that are set out in an orderly way in the Tables of Discovery (partly in this work ·**112–113** and **218**·, but much more in the fourth part of my Great Fresh Start [see note in **31**], because this isn't merely a •hope for the thing but •the thing itself. But I want to come at things gently, so ·instead of jumping straight to the Tables· I shall proceed with my plan of *preparing* men's minds, for **hope** is a significant part even of preparation. If all the other inducements aren't accompanied by **hope**, their effect on men is not to •ginger them up and get them busy but rather to •make them depressed by giving them an even darker view of how things now stand and making them even more fully aware of the unhappiness of their own condition. So there is a point in my revealing and recommending the views of mine that make **hope** in this matter reasonable. It's like what Columbus did *before* his wonderful voyage across the Atlantic, giving reasons for his belief that hitherto unknown lands and continents might be discovered. His reasons were rejected at first, but later they were vindicated by experience, and were the causes and beginnings of great events.

The next post in the sequence, Book 1: 93-130 (The Baconian Method), will be posted Thursday, October 10th at latest by 6:00pm PDT.

The Baconian Method (Novum Organum Book 1: 93-107)

This is the seventh post in the Novum Organum sequence. For context, see the sequence introduction.

In this section, Bacon lists reasons why we should believe much greater progress in science is possible, and in doing so begins to describe his own inductivist methodology in detail.

We have used Francis Bacon's Novum Organum in the version presented at www.earlymoderntexts.com. Translated by and copyright to Jonathan Bennett. Prepared for LessWrong by Ruby.

Ruby's Reading Guide

> Novum Organum is organized as two books each containing numbered "aphorisms." These vary in length from three lines to sixteen pages. Bracketed titles of posts in this sequence, e.g. *Idols of the Mind Pt. 1*, are my own and do not appear in the original.
>
> While the translator, Bennett, encloses his editorial remarks in a single pair of [brackets], I have enclosed mine in a [[double pair of brackets]].

Bennett's Reading Guide

> [Brackets] enclose editorial explanations. Small ·dots· enclose material that has been added, but can be read as though it were part of the original text. Occasional •bullets, and also indenting of passages that are not quotations, are meant as aids to grasping the structure of a sentence or a thought. Every four-point ellipsis . . . . indicates the omission of a brief passage that seems to present more difficulty than it is worth. Longer omissions are reported between brackets in normal-sized type.

Aphorism Concerning the Interpretation of Nature: Book 1: 93–107

by Francis Bacon

93. We have to assume that the force behind everything is God; for our subject matter—·namely nature·—is good in such a way that it plainly comes from God, who is the author of good and the father of light. Now in divine operations even the smallest beginnings lead unstoppably to their end. It was said of spiritual things that 'The kingdom of God cometh not with observation' [*Luke* 17:20], and it is the same with all the greater works of divine providence: everything glides on smoothly and noiselessly, and the work is well under way before men are aware that it has begun. And don't forget Daniel's prophecy concerning the last ages of the world: 'Many shall run to and fro, and knowledge shall be increased' [*Daniel* 12:4], clearly indicating that the thorough exploration of the whole world is fated to coincide with the advancement of the sciences. (By 'fated' I mean 'destined by ·God's· providence'. I would add that there have been so many distant voyages that 'the thorough exploration of the whole world' seems to have reached completion or to be well on the way to it.)

94. Next topic: the best of all reasons for having **hope**, namely *the errors of the past, the wrong roads so far taken*. In the course of censuring a poorly run government the critic said something excellent:

> The worst things in the past ought to be regarded as the best for the future. For if you had conducted yourself perfectly yet still ended up in your present ·miserable· condition, you would have not even a ***hope*** of improvement. But as things stand, with your misfortunes being due not to the circumstances but to your own errors, you can **hope** that by abandoning or correcting these errors you can make a great change for the better.

Similarly, if throughout many years men had gone the right way about discovering and cultivating the sciences, and the sciences had still been in the state they are now actually in, it would have been absurdly bold to think that further progress was possible. But if the wrong road has been taken, and men have worked on things that weren't worthwhile, it follows that the troubles have arisen not from •circumstances that weren't in our power but from •the human intellect—and the use and application of *that* can be remedied. So it will be really useful to expound these errors; because every harm they have done in the past gives us reason to **hope** to do better in the future. I have already said a little about these errors, but I think I should set them out here in plain and simple words.

95. Those who have been engaged in the sciences divide into *experimenters* and *theorists*. The experimenters, like •ants, merely collect and use ·particular facts·; the theorists, like •spiders, make webs out of themselves. But the •bee takes a middle course: it gathers its material from the flowers of the garden and the field, but uses its own powers to transform and absorb this material. A true worker at philosophy is like that:

- he doesn't rely solely or chiefly on the powers of the mind ·like a theorist = spider·, and
- he doesn't take the material that he gathers from natural history and physical experiments and store it up in his memory just as he finds it ·like an experimenter = ant·. Instead,
- he stores the material in his intellect, altered and brought under control.

So there is much to **hope** for from a closer and purer collaboration between these two strands in science, experimental and theoretical—a collaboration that has never occurred before now.

96. We have never yet had a natural philosophy that was pure. What we have had has always been tainted and spoiled: in Aristotle's school by logic; in Plato's by natural theology; in the second school of Platonists (Proclus and others) by mathematics, which ought only to set natural philosophy's limits, not generate it or give it birth. From a pure and unmixed natural philosophy we can **hope** for better things ·than can be expected from any of those impure systems·.

97. No-one has yet been found who was sufficiently firm of mind and purpose to decide on *and to carry out* this programme:

> Clean right out all theories and common notions, and apply the intellect—thus scrubbed clean and evenly balanced—to a fresh examination of particulars.

[[By *particulars,* Bacon likely means something close to specific individual data points and observations.]]

For want of this, the human knowledge that we have is a mish-mash, composed of •childish notions that we took in along with our mothers' milk, together with •·the results of· much credulity and many stray happenings. So if someone of mature years, with functioning senses and a well-purged mind, makes a fresh start on examining experience and particular events, better things may be **hoped** for from him. In this respect, I pledge myself to have good fortune like that of Alexander the Great. Don't accuse me of vanity until you have heard me out, because what I am getting at—taken as a whole—goes *against* vanity. Aeschines said of Alexander and his deeds: 'Assuredly we don't live the life of mortal men. What we were born for was that in after ages wonders might be told of us', as though Alexander's deeds seemed to him miraculous. But ·what I am saying about myself is not like that, but rather like this·: in the next age Livy took a better and a deeper view of the matter, saying of Alexander that 'all he did was to have the courage to neglect sources of fear that were negligible'. I think that a similar judgment may be passed on me in future ages: that I did no great things, but simply cut down to size things that had been regarded as great. . . .

98. We can't do without experience; but so far we haven't had any foundations for experience, or only very weak ones. No-one has searched out and stored up a great mass of particular events that is adequate

- in number,
- in kind,
- in certainty, or
- in any other way

to inform the intellect. On the contrary, learned men— relaxed and idle—have accepted, as having the weight of legitimate evidence for constructing or confirming

their philosophy, bits of hearsay and rumours about experience. Think of a kingdom or state that manages its affairs on the basis not of •letters and reports from ambassadors and trustworthy messengers but of •street-gossip and the gutter! Well, the way philosophy has managed its relations with experience has been *exactly* like that.

- Nothing examined in enough careful detail,
- nothing verified,
- nothing counted,
- nothing weighed,
- nothing measured

is to be found in natural history. And observations that are loose and unsystematic lead to ideas that are deceptive and treacherous. Perhaps you think that this is a strange thing to say. You may want to comment:

> Your complaint is unfair. Aristotle—a great man, supported by the wealth of a great king—composed an accurate natural history of animals; and others, with greater diligence though making less fuss about it, made many additions; while yet others compiled rich histories and descriptions of metals, plants, and fossils.

If so, it seems that you haven't properly grasped what I am saying here. For the rationale of a •natural history that is composed for its own sake is not like the rationale of a •natural history that is collected to supply the intellect with the concepts it needs for building up philosophy. They differ in many ways, but especially in this: the former attends only to the variety of natural species ·as they are found in nature·, not to ·deliberately constructed· experiments in the mechanical arts. In the business of life, the best way to discover a man's character, the secrets of how his mind works, is to see how he handles trouble. In just the same way, nature's secrets come to light better when she is artificially shaken up than when she goes her own way. So we can **hope** for good things from natural philosophy when natural history—which is its ground-floor and foundation—is better organized. Then, but not until then!

99. Furthermore, even when there are plenty of mechanical experiments, there's a great scarcity of ones that do much to enlarge the mind's stock of concepts. The experimental technician isn't concerned with discovering the truth, and isn't willing to raise his mind or stretch out his hand for anything that doesn't bear on his ·practical· project. There will be grounds for **hope** of scientific advances when ·and only when· men assemble a good number of natural-history experiments that •are in themselves of no ·practical· use but simply •serve to discover causes and axioms. I call these 'experiments of light', to distinguish them from the ·practically useful but theoretically sterile· ones that I call 'experiments of fruit' [here 'fruit' = 'practical results']. Now, experiments of this kind have one admirable property: they never miss or fail! Their aim is not to •produce some particular effect but only to •discover the natural cause of something; and such an experiment succeeds equally well however it turns out, for either way it settles the question.

100. Many more experiments should be devised and carried out, and ones of an utterly different kind from any we have had up to now. But that is not all. There should also be introduced an entirely different method, order, and procedure for carrying through a programme of experiments. To repeat something I have already said [**82**]: when experimentation wanders around of its own accord, it merely gropes in the dark and confuses men rather than instructing them. But when there is a firmly regulated, uninterrupted *series* of experiments, there is **hope** for advances in knowledge.

101. Even after we have acquired and have ready at hand a store of natural history and experimental results such as is required for the work of the intellect, or of philosophy, *still* that is not enough. The intellect is far from being able to retain all this material in memory and recall it at will, any more than a man could keep a diary all in his head. Yet until now there has been more *thinking* than *writing* about discovery procedures—experimentation hasn't yet become *literate*! But a discovery isn't worth much if it isn't ·planned and reported· in writing; and when this becomes the standard practice, better things can be **hoped** for from experimental procedures that have at last been made literate.

102. The particulars ·that have to be studied· are very numerous, and are like an army that is dispersed across a wide terrain, threatening to scatter and bewilder the intellect ·that tries to engage with them·. There's not much to be **hoped** for from intellectual skirmishing ·with these particulars·, dashing here and there among them in a disorderly way. What is needed is first •to get the relevant particulars drawn up and arranged, doing this by means of tables of discovery that are well selected, well arranged, and *fresh* (as though living); and •to put the mind to work on the prepared and arranged helps that these tables provide.

[[By *axiom*, Bacon means something akin to *hypothesis* or *model.*]]

103. But after this store of particulars has been laid before our eyes in an orderly way, we shouldn't pass straight on to the investigation and discovery of new particulars or new discoveries; or anyway if we *do* do that we oughtn't to stop there. I don't deny that when all the experiments of all the arts have been collected and ordered and brought within the knowledge and judgment of one man, new useful things may be discovered through taking the experimental results of one art and re-applying them to a different art (using the approach to experiments that I have called 'literate', ·meaning that the results are properly recorded in writing·). But nothing much can be **hoped** for from that procedure. Much more promising is this: from those particular results derive axioms in a methodical manner, then let the light of the axioms point the way to new particulars. For our road does not lie on a level, but goes up and down —up to axioms, then down again to scientific practice.

[[For a modern plain English description of Bacon's method see: **1**, **2**, **3**.

A concrete example of what Bacon is discussing might be as follows:

> Particular: you observe that both parents of sparrows care for their young*.
>
> Highly-General Axiom/Hypothesis: both sexes of all bird species care for the young;
>
> Medium-General Hypothesis: both of sexes small birds care for their young;
>
> Narrow Axiom/Hypotheses: Some of both sexes of sparrows living in South England care for their young.

Aristotle might start with a fews observations or a folk belief that some birds of both sexes care for their young and then formulate a universal truth: *For all X such that X is a bird, it cares for its young*. By syllogism, Aristotle will derive new particular cases: *Robins are are kind of bird therefore box sexes of Robins care for their young.* This is syllogistic demonstration.

Bacon states that the Aristotelian approach is utterly invalid and instead one musts only generalize modestly from observations, using each expansion of the generalization to seek out further evidence which will either confirm or deny further expansion.

*This is a fictitious example.]]

104. But the intellect mustn't be allowed •to jump—to *fly*—from particulars a long way up to axioms that are of almost the highest generality (such as the so-called 'first principles' of arts and of things) and then on the basis of them (taken as unshakable truths) •to 'prove' and thus secure middle axioms. That has been the practice up to now, because the intellect has a natural impetus to do that and has for many years been trained and habituated in doing it by the use of syllogistic demonstration. Our only **hope** for good results in the sciences is for us to proceed thus: using a valid ladder, we move up gradually—not in leaps and bounds—from particulars to lower axioms, then to middle axioms, then up and up until at last we reach the most general axioms. ·The two ends of this ladder are relatively unimportant· because the lowest axioms are not much different from ·reports on· bare experience, while the highest and most general ones—or anyway the ones that we have now—are notional and abstract and without solid content. It's the middle axioms that are true and solid and alive; they are the ones on which the affairs and fortunes of men depend. Above them are the most general axioms, ·which also have value, but· I am talking not about abstract axioms but rather about ones of which the middle axioms are limitations ·and which thus get content from the middle axioms·. So the human intellect should be •supplied not with wings but rather •weighed down with lead, to keep it from leaping and flying. This hasn't ever been done; when it *is* done we'll be entitled to better **hopes** of the sciences.

105. For establishing axioms we have to devise a different form of induction from any that has been use up to now, and it should be used for proving and discovering not only so-called 'first principles' but also the lesser middle axioms— indeed *all* axioms. The induction that proceeds by simply listing positive instances is a childish affair; its conclusions are precarious and exposed to peril from a contradictory instance; and it generally reaches its conclusions on the basis of too few facts—merely the ones that happen to be easily available. A form of induction that will be useful for discovery and demonstration in the sciences and the arts will have •to separate out a nature through appropriate rejections and exclusions, and then, after a sufficient number of negatives, •to reach a conclusion on the affirmative instances. [Bacon will start to explain this in 2-**15**.] No-one has ever done this, or even *tried to*, except for Plato who does indeed make some use of this form of induction for the purpose of discussing definitions and ideas. But for this kind of induction (or demonstration) to be properly equipped for its work, *many* things have to be done that until now no mortal has given a thought to; so that much more work will have to be spent on this than has ever been spent on the syllogism. And this induction should be used not only in the discovery of axioms but also in drawing boundaries around notions. It is in this induction that our chief **hope** lies.

[[Here Bacon again mentions the importance of Looking Into the Dark .]]

106. When establishing an axiom by this kind of induction, we must carefully note whether the axiom is shaped so as to fit only the particulars from which it is derived, rather than being larger and wider. And if it *is* larger and wider, we must see whether its greater scope is confirmed and justified by new particulars that it leads us to. Such a justified increase of scope saves us from being stuck with things that are already

known (but if it isn’t justified then we are over-stretching, loosely grasping at shadows and abstract forms rather than at solid things in the world of matter). When we do things in this way we shall at last have justified **hope**.

107. At this point I should remind you of what I said earlier [**80**] about extending the range of natural philosophy so that the particular sciences can be grounded in it, and the branches of knowledge don’t get lopped off from the trunk. For without that there will be little **hope** of progress.

The next post in the sequence, Book 1: 108-130 (Reasons for Hope & Objection Preemption), will be posted Thursday, October 17 at latest by 4:00pm PDT.

Reasons for Hope & Objection Preemption (Novum Organum Book 1: 108-130)

This is the eighth post in the Novum Organum sequence. For context, see the sequence introduction.

We have used Francis Bacon's Novum Organum in the version presented at www.earlymoderntexts.com. Translated by and copyright to Jonathan Bennett. Prepared for LessWrong by Ruby.

Ruby's Reading Guide

> Novum Organum is organized as two books each containing numbered "aphorisms." These vary in length from three lines to sixteen pages. Bracketed titles of posts in this sequence, e.g. *Idols of the Mind Pt. 1*, are my own and do not appear in the original.
>
> While the translator, Bennett, encloses his editorial remarks in a single pair of [brackets], I have enclosed mine in a [[double pair of brackets]].

Bennett's Reading Guide

> [Brackets] enclose editorial explanations. Small ·dots· enclose material that has been added, but can be read as though it were part of the original text. Occasional •bullets, and also indenting of passages that are not quotations, are meant as aids to grasping the structure of a sentence or a thought. Every four-point ellipsis . . . . indicates the omission of a brief passage that seems to present more difficulty than it is worth. Longer omissions are reported between brackets in normal-sized type.

Aphorism Concerning the Interpretation of Nature: Book 1: 108–130

by Francis Bacon

[[Bacon continues his listing of reasons we should believe much greater scientific progress is possible.]]

108. That's all I have to say about getting rid of despair and creating **hope** by banishing or fixing past errors. Now, what other ways are there of creating **hope**? Here's a thought that occurs at once: Many useful discoveries have been made accidentally by men who weren't looking for *them* but were busy about other things; so no-one can doubt that if men seek for something and are busy about *it*, proceeding in an orderly and not a slapdash way, they will discover far more. Of course it can happen occasionally that someone accidentally stumbles on a result that he wouldn't have found if he had searched hard for it, but on the whole the opposite is the case—·things are discovered by methodical searching that couldn't have been found by accident·. So, far better things, and more of them, and at shorter intervals, are to be **hoped** for from •hard thinking, hard focussed work and concentration than from ••lucky· accidents, undisciplined whims and the like, which until now have been the main source of discoveries.

109. Here is another ground for **hope**: Discoveries have sometimes been made that would have been almost unthinkable in advance, and would have been written off as impossible. Men think about the *new* in terms of the *old*: to questions about what the •future holds they bring an imagination indoctrinated and coloured by the •past. This is a terrible way of forming opinions, because streams fed by nature's springs don't run along familiar channels.

Suppose that before gunpowder was invented someone described it in terms of its effects—'There is a new invention by means of which the strongest towers and walls can be demolished from a long way off'. That would no doubt have set men thinking about how to increase the power of *catapults* and *wheeled ramming devices*. The notion of a fiery blast suddenly and forcefully expanding and exploding would hardly have entered into any man's mind or imagination, because nothing closely analogous to that had ever been seen. Well, except perhaps in earthquakes and lightning, but *they* wouldn't have been seen as relevant because they are mighty works of *nature* which *men* couldn't imitate.

Or suppose that before the discovery of silk someone had said: 'They've discovered new a kind of thread for use in clothing and furniture-coverings; it is finer, softer, more beautiful and *stronger* than linen or wool.' Men would have begun to think of some silky kind of plant or of very fine hair of some animal or of the feathers and down of birds; they would *not* have thought of a web woven by a tiny worm in great quantities and renewing itself yearly. If anyone *had* said anything about a worm, he'd have been laughed at as dreaming of a new kind of cobweb! [Bacon then gives a third example: the magnet.] Yet these things and others like them lay concealed from men for centuries, and when they did come to light it wasn't through science or any technical skill but by accident and coincidence. As I have remarked, they were so *utterly*

different in kind from anything previously known that they couldn't possibly have been discovered through a preconceived notion of them.

So there are strong grounds for **hoping** that nature has concealed in its folds many wonderfully useful •things that aren't related to or parallel with anything that is now known, and lie right outside our imaginative reach. As the centuries roll on, •they too will doubtless come to light of their own accord in some roundabout way, as did gunpowder and the others; but by the method I am discussing they can be presented and anticipated speedily, suddenly and all at once.

110. Other discoveries prove that this can happen: splendid discoveries are lying at our feet, and we step over them without seeing them. The discoveries of

- gunpowder,
- silk,
- the magnet,
- sugar,
- paper,

or the like may seem to depend on certain properties of things of and nature—·properties that might have been hard to discover·. But there is nothing in *printing* that isn't wide open and almost easy. All that was needed was to see that

- although it is harder to arrange letter-types than to write by hand, the two procedures differ in that once the types have been arranged any number of impressions can be made from them, whereas hand-writing provides only a single copy,

and to see that

- ink can be so thickened so that it does its job but doesn't run, especially when the type faces upwards and the ink is rolled onto it from above.

It was merely because they didn't notice *these* ·obvious· facts that men went for so many ages without this most beautiful invention which is so useful in the spreading of knowledge.

But the human mind is such a mess when it comes to this business of discoveries that it first •distrusts and then •despises itself:

- before the discovery: it is not credible that any such thing can be found,
- afterwards: it is incredible that the world should have missed it for so long!

And this very thing entitles us to some **hope**, namely the hope that there is a great mass of discoveries still to be made—not just ones that will have to be dug out by techniques that we don't yet have, but also ones that may come to light through our transferring, ordering and applying things that we do know already, this being done with the help of the experimental approach that I call 'literate' [**101**].

111. Another ground of **hope** should be mentioned. Let men reflect on their infinite expenditure of intellect, time, and means on things of *far* less use and value ·than the discoveries I am talking about·. If even a small part of this were directed to sound and solid studies, there is no difficulty that couldn't be overcome. I mention this ·matter of the use of resources· because a collection of Natural and Experimental History, as I

envisage it and as it ought to be, is a great—as it were, a *royal*—work, and I freely admit that it will involve much labour and expense.

[It will appear in Book **2-11** that the 'collection' Bacon talks of is an orderly written account of phenomena, experiments and their results, not a physical museum.]

112. In the meantime, don't be put off by *how many* particulars there are; rather, let this give you **hope**. ·The fact is that you will be in worse trouble if you *don't* engage with them·; for the •particular phenomena of nature are a mere handful compared to the ·great multitudes of· •things that human ingenuity can fabricate if it cuts itself off from the clarifying effects of reality. And this road ·through the study of *real* events· soon leads to open ground, whereas the other—·the route through *invented* theories and thought-experiments·— leads to nothing but endless entanglement. Until now men haven't lingered long with •experience; they have brushed past it on their way to the ingenious •theorizings on which they have wasted unthinkable amounts of time. But if we had someone at hand who could answer our questions of the form 'What are the *facts* about this matter?', it wouldn't take many years for us to discover all causes and complete every science [the Latin literally means 'to discover all causes and sciences'].

113. Men may take some **hope**, I think, from my own example (I'm not boasting; just trying to be useful). If you are discouraged ·about the chances of progress in the sciences·, look at me!

- I am busier with affairs of state than any other man of my time,
- I lose a lot of time to ill-health, and
- in this ·scientific· work I am wholly a pioneer, not following in anyone's tracks and not getting advice from anyone.

And yet, ·despite these three sources of difficulty·, I think I have pushed things on a certain amount by sticking to the true road and submitting my mind to reality. Well, then, think what might be expected (now that I have pointed out the way) from men

- with plenty of free time,
- ·in good health·, and
- working together, on the basis of previous work ·by others·.

Unlike the work of sheerly *thinking up* hypotheses, proper scientific work *can* be done collaboratively; the best way is for men's efforts (especially in collecting experimental results) to be exerted separately and then brought together. Men will begin to know their strength only when they go this way—with one taking charge of one thing and another of another, instead of all doing all the same things.

114. Lastly, even if the breeze of **hope** that blows on us from that New Continent were fainter and less noticeable than it is, still we have to *try*—unless we prefer to have minds that are altogether abject! The loss that may come from •not trying is much greater than what may come from ·trying and· •not succeeding: by •not trying we throw away the chance of an immense good; by •not succeeding we only incur the loss of a little human labour. But from what I have said (and from some things that I *haven't* said) it seems to me that there is more than enough **hope** not only •to get a vigorous man to *try* but also to make a sober-minded and wise man *believe* ·that he will succeed·.

115. That completes what I wanted to say about getting rid of the pessimism that has been one of the most powerful factors delaying and hindering the progress of the

sciences. I have also finished with the signs and causes of errors, of sluggishness and of the prevailing ignorance. ·I've said more about this than you might think·, because the more subtle causes—the ones that aren't generally noticed or thought about—come under what I said about the 'idols' of the human mind.

And this should also bring to an end the part of my Great Fresh Start [see note in **31**] that is devoted to *rejection*, which I have carried out through three refutations:

(1) the refutation of innate human reason left to itself [see Preface];
(2) the refutation of demonstrations [see **44** and **69**];
(3) the refutation of the accepted philosophical doctrines [see **60–62**].

I refuted these in the ·only· way I *could* do so, namely through signs and the evidence of causes. I couldn't engage in any other kind of confutation because I differ from my opponents both on first principles and on rules of demonstration.

So now it is time to proceed to the actual techniques for interpreting nature and to the rules governing them—except that there is *still* something that has to be said first! In this first book of aphorisms my aim has been to prepare men's minds not just for •*understanding* what was to follow but for •*accepting* it; and now that I have •cleared up and washed down and levelled the floor of the mind, I have to •get the mind into a good attitude towards the things I am laying before it—to *look kindly* on them, as it were. ·This has to be worked for·, because anything new will be confronted by prejudgments ·against it·, not only ones created by old opinions but also ones created by false ideas about what the new thing is going to be. So I shall try to create sound and true opinions about what I am going to propose; but this is only a stop-gap expedient—a kind of security deposit—to serve until I can make the stuff itself thoroughly known.

116. First, then, don't think that I want to found a new sect in philosophy—like the ancient Greeks and like some moderns such as Telesio, Patrizzi or Severinus. For that's not what I am up to; and I really don't think that human welfare depends much on what abstract opinions anyone has about nature and its workings. No doubt many old theories of this sort can be revived and many new ones introduced, just as many theories of the heavens can be supposed that fit the phenomena well enough but differ from each other; but I'm not working on such useless speculative matters.

My purpose, rather, is to see whether I can't provide humanity's power and greatness with firmer foundations and greater scope. I have achieved some results—scattered through some special subjects—that I think to be far more true and certain and indeed more fruitful than any that have so far been used (I have collected them in the •fifth part of my Fresh Start); but I don't yet have a complete theory of everything to propound. It seems that the time hasn't come for that. I can't hope to live long enough to complete the •sixth part (which is to present science discovered through the proper interpretation of nature); but I'll be satisfied if in the middle parts I conduct myself soberly and usefully, sowing for future ages the seeds of a purer truth, and not shying away from the start of great things. [See note in **31**.]

117. Not being the founder of a sect, I am not handing out bribes or promises of particular works. You may indeed think that because I talk so much about 'works' ·or 'results'· and drag everything over to *that*, I should produce some myself as a down-payment. Well, I have already clearly said it many times, and am happy now to say it again: my project is not to get

works from works or
experiments from experiments (like the •empirics),

but rather to get

causes and axioms from works and experiments,

and then to get

new works and experiments from those causes and axioms (like the •legitimate interpreters of nature).

[An 'empiric' is someone who is interested in *what* works but not in *why* it works; especially a physician of that sort, as referred to by Locke when he speaks of 'swallowing down opinions as silly people do empirics' pills, without knowing what they are made of or how they will work'.]

If you look at

- my Tables of Discovery that ·will· constitute the fourth part of the Fresh Start, and
- the examples of particulars that I present in the second part, ·i.e. the present work·, and
- my observations on the history that I ·will· sketch in the third part,

you won't need any great intellectual skill to see indications and outlines of many fine results all through this material; but I openly admit that the natural history that I have so far acquired, from books and from my own investigations, is too skimpy, and not verified with enough accuracy, to serve the purposes of legitimate interpretation.

To anyone who is abler and better prepared ·than I am· for mechanical pursuits, and who is clever at getting results from experiment, I say: By all means go to work snipping off bits from my history and my tables and apply them to getting results—this could serve as *interest* until the *principal* is available. But I am hunting for bigger game, and I condemn all hasty and premature interruptions for such things as these, which are (as I often say) like Atalanta's spheres. I don't go dashing off after golden apples, like a child; I bet everything on art's winning its race against nature. [On Atalanta and the race see **70**.] I don't scurry around clearing out moss and weeds; I wait for the harvest when the crop is ripe.

118. When my history and Tables of Discovery are read, it will surely turn out that some things in the experiments themselves are not quite certain or perhaps even downright false, which may lead you to think that the foundations and principles on which my discoveries rest are ·also· false and doubtful. But this doesn't matter, for such things are bound to happen at first. It's like a mere typographical error, which doesn't much hinder the reader because it is easy to correct as you read. In the same way, ·my· natural history may contain many experiments that are false, but it won't take long for them to be easily expunged and rejected through the discovery of causes and axioms. It is nevertheless true that if big mistakes come thick and fast in a natural history, they can't possibly be corrected or amended through any stroke of intelligence or skill. Now, my natural history has been collected and tested with great diligence, strictness and almost *religious* care, yet there may be errors of detail tucked away in it; so what should be said of run-of-the-mill natural history, which is so careless and *easy* in comparison with mine? And what of the philosophy and sciences

built on that kind of sand (or rather *quicksand*)? So no-one should be troubled by what I have said.

119. My history and experiments will contain many things that are

- trivial, familiar and ordinary, many that are
- mean and low [see **120**], and many that are
- extremely subtle, merely speculative, and seemingly useless [see **121**].

Such things could lead men to lose interest or to become hostile ·to what I have to offer. I shall give these one paragraph each·.

Men should bear in mind that until now *their* activities have consisted only in explaining unusual events in terms of more usual ones, and they have simply taken the usual ones for granted, not asking what explains *them*. So they haven't investigated the causes of

- weight,
- rotation of heavenly bodies,
- heat,
- cold,
- light,
- hardness,
- softness,
- rarity,
- density,
- liquidity,
- solidity,
- life,
- lifelessness,
- similarity,
- dissimilarity,
- organicness,

and the like. They have accepted these as self-evident and obvious, and have devoted their inquiring and quarrelling energies to less common and familiar things.

But I *have to* let the most ordinary things into my history, because I know that until we have properly looked for and found the causes of common things and the causes of those causes, we can't make judgments about uncommon or remarkable things, let alone bring anything new to light. Indeed, I don't think that anything holds up philosophy more than the fact that common and familiar events don't cause men to stop and think, but are received casually with no inquiry into their causes. A result of this we need •to pay attention to things that are known and familiar at least as often as •to get information about unknown things.

120. As for things that are low or even filthy: as Pliny says, these should be introduced with an apology, but they should be admitted into natural history just as the most splendid and costly things should. And that doesn't pollute the natural history that admits them; the sun enters the sewer as well as the palace, but isn't polluted by that! I am not building a monument dedicated to human glory or erecting a pyramid in its honour; what I'm doing is to lay a foundation for a holy temple in the human intellect—a temple modelled on the world. So I follow that model, because whatever is worthy of *being* is worthy of *scientific knowledge*, which is the image or likeness of being; and low things *exist* just as splendid ones do. And another point:

just as from certain putrid substances such as musk and civet the sweetest odours are sometimes generated, so also mean and sordid events sometimes give off excellent and informative light. That is enough about this; *more* than enough, because this sort of squeamishness is downright childish and effeminate.

121. The third objection must be looked into much more carefully. I mean the objection that many things in my history will strike ordinary folk, and indeed ·non-ordinary· ones trained in the presently accepted systems, as intricately subtle and *useless*. It is especially because of this objection that I have said, and should ·again· say, that in the initial stages ·of the inquiry· I am aiming at experiments of light, not experiments of fruit [see **99**]. In this, as I have often said [see **70**], I am following the example of the divine creation which on the first day produced nothing but light, and gave that a day to itself without doing any work with matter. To suppose, therefore, that things like these ·'subtleties' of mine· are useless is the same as supposing that light is useless because it isn't a *thing*, isn't solid or material. And well-considered and well-delimited knowledge of simple natures is like light: it gives entrance to all the secrets of nature's workshop, and has the power to gather up and draw after it whole squadrons of works and floods of the finest axioms; yet there is hardly anything we can *do with it* just in itself. Similarly the •letters of the alphabet taken separately are useless and meaningless, yet they're the basic materials for the planning and composition of all discourse. So again the •seeds of things have much latent power, but nothing comes of it except in their development. And ·light is like scientific subtleties in another way, namely·: the scattered rays of light don't do any good unless they are made to converge.

If you object to speculative subtleties, what will you say about the schoolmen [= 'mediaeval and early modern Aristotelians'], who have wallowed in subtleties? And *their* subtleties were squandered on •words (or on popular notions—same thing!) rather than on •facts or nature; and they were useless the whole way through, unlike mine, which are indeed useless right now but which promise endless benefits later on. But this is sure, and you should know it:

> All subtlety in disputations and other mental bustling about, if it occurs after the axioms have been discovered, comes too late and has things backwards. The true and proper time for subtlety, or anyway the chief time for it, is when pondering experiments and basing axioms on them.

For that other ·later· subtlety grasps and snatches at [*captat*] nature but can never get a grip on [*capit*] it. . . .

A final remark about the lofty dismissal from natural history of everything •common, everything •low, everything •subtle and as it stands useless: When a haughty monarch rejected a poor woman's petition as unworthy thing and beneath his dignity, she said: 'Then leave off being king.' That may be taken as an oracle. For someone who won't attend to things like •these because they are too paltry and minute can't take possession of the kingdom of nature and can't govern it.

122. This may occur to you: 'It is amazing that you have the nerve to push aside all the sciences and all the authorities at a single blow, doing this single-handed, without bringing in anything from the ancients to help you in your battle and to guard your flanks.'

Well, I know that if I had been willing to be so dishonest, I could easily have found support and honour for my ideas by referring them either •to ancient times before the

time of the Greeks (when natural science may have flourished more ·than it did later·, though *quietly* because it hadn't yet been run through the pipes and trumpets of the Greeks), or even, in part at least, •to some of the Greeks themselves. This would be like the men of no family who forge genealogical tables that 'show' them to come from a long line of nobility. But I am relying on the evidentness of ·the truth about· things, and I'll have nothing to do with any form of fiction or fakery. Anyway, it *doesn't matter* for the business in hand whether the discoveries being made now •were known to the ancients long ago and •have alternately flourished and withered through the centuries because of the accidents of history (just as it doesn't matter to mankind whether the New World is the island of Atlantis that the ancients knew about or rather is now discovered for the first time). It doesn't matter because *discoveries*—·even if they are *re*discoveries·—have to be sought [*petenda*] from the light of nature, not called back [*repetenda*] from the shadows of antiquity.

As for the fact that I am finding fault with everyone and everything: when you think about it you'll see that *that* kind of censure is more likely to be right than a partial one would be—and less damaging, too. For a partial censure would imply that the errors were not rooted in primary notions, and that there had been some true discoveries; they could have been used to correct the false results, ·and the people concerned would have been to blame for not seeing this·. But in fact the errors were fundamental; they came not so much from false judgment as from not attending to things that should be attended to; so it's no wonder that men haven't obtained what they haven't tried for, haven't reached a mark that they never set up, haven't come to the end of a road that they never started on.

As for the insolence that ·you might think· is inherent in what I am doing: if a man says that

> •his steady hand and good eyes enable him to draw a straighter line or a more perfect circle than anyone else,

he is certainly •making a comparison of abilities; but if he says only that

> •with the help of a ruler or a pair of compasses can draw a straighter line or a more perfect circle than anyone else can by eye and hand alone,

he isn't •making any great boast. And I'm saying this not only about these first initiating efforts of mine but also about everyone who tackles these matters in the future. For my route to discovery in the sciences puts men on the same intellectual level, leaving little to individual excellence, because it does everything by the surest rules and demonstrations. So I attribute my part in all this, as I have often said, to good luck rather than to ability—it's a product of *time* rather than of *intelligence*. For there's no doubt that luck has something to do with men's thoughts as well as with their works and deeds.

123. Someone once said jokingly 'It can't be that we think alike, when one drinks water and the other drinks wine'; and this nicely fits my present situation. Other men, in ancient as well as in modern times, have done their science drinking a crude liquor —like water

> **(1)** flowing spontaneously from a spring or **(2)** hauled up by wheels from a well,
> **(1)**flowing spontaneously from the intellect or **(2)** hauled up by logic.

Whereas I drink a toast with a liquor strained from countless grapes, ripe and fully seasoned ones that have been gathered and picked in clusters, squeezed in the press,

and finally purified and clarified in the vat. No wonder I am at odds with the others!

124. This also may occur to you: 'You say it against others, but it can be said against you, that the goal and mark that you have set up for the sciences is not the true or the best.' ·The accusation would develop like this·:

> Contemplation of *the truth* is a worthier and loftier thing than thinking about how *big and useful* one's practical results will be. Lingering long and anxiously on •experience and •matter and •the buzz of individual events drags the mind down to earth, or rather sinks it to an underworld of turmoil and confusion, dragging it away from a much more heavenly condition—the serene tranquillity of abstract wisdom.

Now I *agree* with this line of thought; what the objectors here point to as preferable is what I too am after, above everything else. For I am laying down in the human intellect the foundations for a *true model of the world*—the world as it turns out to be, not as one's reason would like it to be. This can't be done unless the world is subjected to a very diligent dissection and anatomical study. As for the stupid models of the world that men have dreamed up in philosophical systems—like the work of *apes*!—they should be utterly scattered to the winds. You need to know what a big difference there is (as I said above [**23**]) between the •idols of the human mind and the •ideas in the divine mind. The former are merely arbitrary abstractions; the latter are the creator's little seals on the things he has created, stamped into matter in true and exquisite lines. In these matters, therefore, truth and usefulness are the very same thing; and practical applications ·of scientific results· are of greater value as pledges of truth than as contributing to the comforts of life.

125. Or you may want to say this: 'You are only doing what the ancients did before you; so that you are likely, after all this grinding and shoving, to end up with one of the systems that prevailed in ancient times.' The case for this goes as follows:

> The ancients also provided at the outset of their speculations a great store and abundance of examples and particulars, sorted out and labelled in notebooks; then out of them they constructed their systems and techniques; and when after that they had checked out everything they published their results to the world with a scattering of examples for proof and illustration; but they saw no need to take the considerable trouble of publishing their working notes and details of experiments. So they did what builders do: after the house was built they removed the scaffolding and ladders out of sight.

I'm sure they did! But this objection (or misgiving, rather) will be easily answered by anyone who hasn't completely forgotten what I have said above. The form of inquiry and discovery that the ancients used—they declared it openly, and it appears on the very face of their writings—was simply this:

> From a few examples and particulars (with some common notions thrown in, and perhaps some of the most popular accepted opinions). they rushed to the most general conclusions, the ·would-be· first principles of ·their· science. Taking the truth of *these* as fixed and immovable, they proceeded to derive from them—through intermediate propositions— lower-level conclusions out of which they built their system. Then if any new particulars and examples turned up that didn't fit their views, they either •subtly moulded them into their system by distinctions or explanations of their rules, or •coarsely got rid of them by ·tacking· exceptions ·onto their principles·. As for particulars that weren't in conflict ·with their views·,

> they laboured away through thick and thin to assign them causes in conformity with their principles.

But this wasn't the experimental natural history that was wanted; far from it. And anyway dashing off to the highest generalities ruined everything.

126. will occur to you too: 'By forbidding men to announce principles and take them as established until they have arrived at the highest generalities in the right way through intermediate steps, you are inviting them to *suspend judgment*, bringing this whole affair down to Acatalepsy.' Not so. What I have in mind and am propounding is not Acatalepsy [from Greek, = 'the doctrine that nothing can be understood'] but rather Eucatalepsy [from Greek, = 'the provision of what is needed for things to be understood']. I don't •disparage the senses, I •serve them; I don't •ignore the intellect, I •regulate it. And it is surely better that we should

> know everything that we need to know, while thinking that our knowledge doesn't get to the heart of things

than that we should

> think our knowledge gets to the heart of things, while we don't yet know anything we need to know.

127. You may want to ask—just as a query, not an objection—whether I am talking only about natural philosophy, or whether instead I mean that the other sciences—logic, ethics and politics—should be conducted in my way. Well, I certainly mean what I have said to apply to them all. Just as •common logic (which rules things by syllogisms) extends beyond natural sciences to all sciences, so does •mine (which proceeds by induction) also embrace everything. I am constructing a history and table of discovery for

> •anger, fear, shame, and the like; for
> •matters political; and for
> •the mental operations of memory, composition and division, judgment and the rest,

just as much as for

> •heat and cold, light, vegetative growth and the like.

But my method of interpretation ·differs from the common logic in one important respect; my method·, after the history has been prepared and set in order, concerns itself not only with •the movements and activities of the mind (as the common logic does) but also with •the nature of things ·outside the mind·. I guide the mind so that its way of engaging with any particular thing is always appropriate. That's why my doctrine of interpretation contains many different instructions, fitting the discovery-method according to the quality and condition of the subject-matter of the inquiry.

128. 'Do you want to pull down and destroy the philosophy, arts and sciences that are now practised?' There ought to be no question about that. Far from wanting to destroy them, I am very willing to see them used, developed and honoured. I don't want to get in the way of their •giving men something to dispute about, •supplying decoration for discourse, •providing the 'experts' with an income, and •facilitating civil life—acting, in short, like coins that have value because men agree to give it to them. Let me clear about this: what I am presenting won't be much use for purposes such as those, since

it can't be brought within reach of the minds of the vulgar except ·indirectly·, through effects and works. My published writings, especially my *Two Books on the Advancement of Learning*, show well enough the sincerity of my declaration of friendly good will toward the accepted sciences, so I shan't expend more words on that topic here. Meanwhile I give clear and constant warning that the methods now in use won't lead to any great progress in the theoretical parts of the sciences, and won't produce much in the way of applied-science results either.

129. All that remains for me to say are a few words about the excellence of the end in view. If I had said them earlier they might have seemed like mere *prayers*; but perhaps they'll have greater weight now, when hopes have been created and unfair prejudices removed. I wouldn't have said them even now if I had done the whole job myself, not calling on anyone else to help with the work, because ·words said in praise of the object of this exercise· might be taken as a proclamation of my own deserts. But ·I'm not going it alone·; I do want to energize others and kindle their zeal, so it is appropriate that I put men in mind of some things, ·even at the risk of *seeming* to boast·.

The making of great ·scientific· discoveries seems to have pride of place among human actions. That was the attitude of the ancients: they honoured the makers of discoveries as though they were *gods*, but didn't go higher than *demigods* in their honours for those who did good service in the state (founders of cities and empires, legislators, saviours of their country from long endured evils, quellers of tyrannies, and the like). And if you think accurately about the two ·kinds of benefactor· you will see that the ancients were right about them. Why? **(1)** Because the benefits of ·scientific· discoveries can •extend to the whole of mankind, and can •last for all time, whereas civil benefits •apply only to particular places and •don't last for very long.

(2) Also, improvements in civil matters usually bring violence and confusion with them, whereas ·scientific· discoveries bring delight, and confer benefits without causing harm or sorrow to anyone.

·Scientific· discoveries are like new creations, imitations of God's works. . . . It seems to be worth noting that Solomon, the marvel of the world, though mighty in empire and in gold, in the magnificence of his works, his court, his household, his fleet, and the lustre of his name, didn't glory in any of these, but pronounced that 'It is the glory of God to conceal a thing; but the honour of kings is to search out a matter' (*Proverbs* 25:2).

If you compare how men live in the most civilized provinces of Europe with how they live in the wildest and most barbarous areas of the American continent, you will think the difference is big enough—the difference in •the condition of the people in themselves as well as in •what conveniences and comforts they have available to them—to justify the saying that 'man is a god to man'. And this difference doesn't come from the Europeans' having better soil, a better climate, or better physiques, but from the arts [see note on 'art' here].

Notice the *vigour* of discoveries, their power to generate consequences. This is nowhere more obvious than in three discoveries that the ancients didn't know and whose origins (all quite recent) were obscure and humdrum. I am talking about the arts of •printing, •gunpowder, and •the nautical compass. These three have changed the whole aspect and state of things throughout the world—the first in literature, the second in warfare, the third in navigation—bringing about countless changes; so that there seems to have been no empire, no philosophical system, no star that has

exerted greater power and influence in human affairs than these mechanical discoveries.

For my next point, I need to distinguish the three kinds— three *levels*, as it were—of human ambition. **(1)** Some people want to extend their power within their own country, which is a commonplace and inferior kind of ambition. **(2)** Some work to extend the power and dominion of their country in relation to mankind in general; this is certainly not as base as **(1)** is, but it is just as much a case of greed. **(3)** If a man tries to get mankind's power and control over the universe off to a fresh start, and to extend it, *his*ambition (if it is ambition at all) is certainly more wholesome and noble ·than the other two·. Now—·this being the point I wanted to make·—man's control over things depends wholly on the arts and sciences, for we can't command nature except by obeying her.

A further point: it sometimes happens that •one particular discovery is so useful to mankind that the person who made it and thus put the whole human race into his debt is regarded as superhuman; so how much higher a thing it is to discover something through which •everything else can easily be discovered! ·Not that a discovery's consequences are the main thing about it·. *Light* is useful in countless ways, enabling us to walk, practise our arts, read, recognize one another, and yet something that is finer and lovelier than all those uses of light is *seeing light*. Similarly, merely contemplating things as they are, without superstition or imposture, error or confusion, is in itself worthier than all the practical upshots of discoveries.

Final point: If anyone counts it against the arts and sciences that they can be debased for purposes of wickedness, luxury, and the like, don't be influenced by that. The same can be said of all earthly goods: intelligence, courage, strength, beauty, wealth —even *light*! Just let the human race get back the right over nature that God gave to it, and give it scope; how it is put into practice will be governed by sound reason and true religion.

130. The time has come for me to present the art of interpreting nature—the art itself, ·not just remarks about the need for it, its virtues, and so on·. Although I think I have given true and most useful precepts in it, I don't say that this art is absolutely necessary, implying that nothing could be done without it. In fact, I think that if

> •men had ready at hand a sound history of nature and of experiments, •were thoroughly practised in it, and •imposed on themselves two rules: **(1)** set aside generally accepted opinions and notions, and **(2)** for a while keep your mind away from the highest and second-to-highest generalizations,

they would arrive at my form of interpretation sheerly through their own natural intelligence, with no help from any other rules or techniques. For interpretation is the true and natural work of the mind when it is freed from blockages. It is true, however, that it can all be done more readily and securely with help from my precepts.

And I don't say, either, that my art of interpreting nature is complete so that nothing can be added to it. On the contrary: I am concerned with the mind not only in respect of its own capacities but also in respect of how it engages with things; so I have to think that the art of discovery can develop as more discoveries are made.

The next post in the sequence will be posted Thursday, October 24 at latest by 4:00pm PDT.