The Method of Induction

Francis Bacon

THE NEW ORGANON
BOOK I

18. The discoveries which have hitherto been made in the sciences are such as lie close to vulgar notions, scarcely beneath the surface. In order to penetrate into the inner and further recesses of nature, it is necessary that both notions and axioms be derived from things by a more sure and guarded way, and that a method of intellectual operation be introduced altogether better and more certain.

19. There are and can be only two ways of searching into and discovering truth. The one flies from the senses and particulars to the most general axioms, and from these principles, the truth of which it takes for settled and immovable, proceeds to judgment and to the discovery of middle axioms. And this way is now in fashion. The other derives axioms from the senses and particulars, rising by a gradual and unbroken ascent, so that it arrives at the most general axioms last of all. This is the true way, but as yet untried.

20. The understanding left to itself takes the same course (namely, the former) which it takes in accordance with logical order. For the mind longs to spring up to positions of higher generality, that it may find rest there, and so after a little while wearies of experiment. But this evil is increased by logic, because of the order and solemnity of its disputations.

21. The understanding left to itself, in a sober, patient, and grave mind, especially if it be not hindered by received doctrines, tries a little that other way, which is the right one, but with little progress, since the understanding, unless directed and assisted, is a thing unequal, and quite unfit to contend with the obscurity of things.

22. Both ways set out from the senses and particulars, and rest in the highest generalities; but the difference between them is infinite. For the one just glances at experiment and particulars in passing, the other dwells duly and orderly among them.

The one, again, begins at once by establishing certain abstract and useless generalities, the other rises by gradual steps to that which is prior and better known in the order of nature.

23. There is a great difference between the Idols of the human mind and the Ideas of the divine. That is to say, between certain empty dogmas, and the true signatures and marks set upon the works of creation as they are found in nature.

24. It cannot be that axioms established by argumentation should avail for the discovery of new works, since the subtlety of nature is greater many times over than the subtlety of argument. But axioms duly and orderly formed from particulars easily discover the way to new particulars, and thus render sciences active.

25. The axioms now in use, having been suggested by a scanty and manipular experience

and a few particulars of most general occurrence, are made for the most part just large enough to fit and take these in; and therefore it is no wonder if they do not lead to new particulars. And if some opposite instance, not observed or not known before, chance to come in the way, the axiom is rescued and preserved by some frivolous distinction; whereas the truer course would be to correct the axiom itself.

26. The conclusions of human reason as ordinarily applied in matters of nature, I call for the sake of distinction *Anticipations of Nature* (as a thing rash or premature). That reason which is elicited from facts by a just and methodical process, I call *Interpretation of Nature*.

27. Anticipations are a ground sufficiently firm for consent, for even if men went mad all after the same fashion, they might agree one with another well enough.

28. For the winning of assent, indeed, anticipations are far more powerful than interpretations, because being collected from a few instances, and those for the most part of familiar occurrence, they straightway touch the understanding and fill the imagination; whereas interpretations, on the other hand, being gathered here and there from very various and widely dispersed facts, cannot suddenly strike the understanding; and therefore they must needs, in respect of the opinions of the time, seem harsh and out of tune, much as the mysteries of faith do.

29. In sciences founded on opinions and dogmas, the use of anticipations and logic is good; for in them the object is to command assent to the proposition, not to master the thing.

30. Though all the wits of all the ages should meet together and combine and transmit their labors, yet will no great progress ever be made in science by means of anticipations; because radical errors in the first concoction of the mind are not to be cured by the excellence of functions and subsequent remedies.

31. It is idle to expect any great advancement in science from the superinducing and engrafting of new things upon old. We must begin anew from the very foundations, unless we would revolve forever in a circle with mean and contemptible progress.

32. The honor of the ancient authors, and indeed of all, remains untouched, since the comparison I challenge is not of wits or faculties, but of ways and methods, and the part I take upon myself is not that of a judge, but of a guide.

33. This must be plainly avowed: no judgment can be rightly formed either of my method or of the discoveries to which it leads, by means of anticipations (that is to say, of the reasoning which is now in use); since I cannot be called on to abide by the sentence of a tribunal which is itself on trial.

34. Even to deliver and explain what I bring forward is no easy matter, for things in themselves new will yet be apprehended with reference to what is old.

35. It was said by Borgia of the expedition of the French into Italy, that they came with chalk in their hands to mark out their lodgings, not with arms to force their way in. I in like manner would have my doctrine enter quietly into the minds that are fit and capable of receiving it; for confutations cannot be employed when the difference is upon first principles and very notions, and even upon forms of demonstration.

36. One method of delivery alone remains to us which is simply this: we must lead men to the particulars themselves, and their series and order; while men on their side must force themselves for a while to lay their notions by and begin to familiarize themselves with facts.

37. The doctrine of those who have denied that certainty could be attained at all has some agreement with my way of proceeding at the first setting out; but they end in being infinitely separated and opposed. For the holders of that doctrine assert simply that nothing can be known. I also assert that not much can be known in nature by the way which is now in use. But then they go on to destroy the authority of the senses and understanding; whereas I proceed to devise and supply helps for the same….

BOOK II

10. Now my directions for the interpretation of nature embrace two generic divisions: the one how to educe and form axioms from experience; the other how to deduce and derive new experiments from axioms. The former again is divided into three ministrations: a ministration to the sense, a ministration to the memory, and a ministration to the mind or reason.

For first of all we must prepare a natural and experimental history, sufficient and good; and this is the foundation of all, for we are not to imagine or suppose, but to discover, what nature does or may be made to do.

But natural and experimental history is so various and diffuse that it confounds and distracts the understanding, unless it be ranged and presented to view in a suitable order. We must therefore form tables and arrangements of instances, in such a method and order that the understanding may be able to deal with them.

And even when this is done, still the understanding, if left to itself and its own spontaneous movements, is incompetent and unfit to form axioms, unless it be directed and guarded. Therefore in the third place we must use induction, true and legitimate induction, which is the very key of interpretation. But of this, which is the last, I must speak first, and then go back to the other ministrations.

11. The investigation of forms proceeds thus: a nature being given, we must first of all have a muster or presentation before the understanding of all known instances which agree in the same nature, though in substances the most unlike. And such collection must be made in the manner of a history, without premature speculation, or any great amount of subtlety. For example, let the investigation be into the form of heat.

Instances Agreeing in the Nature of Heat

1. The rays of the sun, especially in summer and at noon.
2. The rays of the sun reflected and condensed, as between mountains, or on walls, and most of all in burning glasses and mirrors.
3. Fiery meteors.
4. Burning thunderbolts.
5. Eruptions of flame from the cavities of mountains.
6. All flame.
7. Ignited solids.
8. Natural warm baths.
9. Liquids boiling or heated….

This table I call the *Table of Essence and Presence*.

12. Secondly, we must make a presentation to the understanding of instances in which the given nature is wanting; because the form, as stated above, ought no less to be absent when the given nature is absent, than present when it is present. But to note all these would be endless.

The negatives should therefore be subjoined to the affirmatives, and the absence of the given nature inquired of in those subjects only that are most akin to the others in which it is present and forthcoming. This I call the *Table of Deviation, or of Absence in Proximity*.

Instances in Proximity where the Nature of Heat is Absent

(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 observed to be at the full moons.

The larger fixed stars, however, when passed or approached by the sun, are supposed to increase and give intensity to the heat of the sun, as is the case when the sun is in the sign Leo, and in the dog days.

(2) The rays of the sun in what is called the middle region of the air do not give heat; for which there is commonly assigned not a bad reason, viz., that that region is neither near enough to the body of the sun from which the rays emanate, nor to the earth from which they are reflected. And this appears from the fact that on the tops of mountains, unless they are very high, there is perpetual snow. On the other hand, it has been observed that on the Peak of Tenerife, and among the Andes of Peru, the very tops of the mountains are free from snow, which lies only somewhat lower down. Moreover, the air itself at the very top is found to be by no means cold, but only rare and keen; insomuch that on the Andes it pricks and hurts the eyes by its excessive keenness, and also irritates the mouth of the stomach, producing vomiting. And it was observed by the ancients that on the top of Olympus the rarity of the air was such that those who ascended 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, the air being from its rarity not sufficient to support respiration; and it was further stated that on this summit the air was so serene, and so free from rain and snow and wind, that letters traced by the finger in the ashes of the sacrifices on the altar of Jupiter remained there still the next year without being at all disturbed. And at this day travelers ascending to the top of the Peak of Tenerife make the ascent by night and not by day, and soon after the rising of the sun are warned and urged by their guides to come down without delay, on account of the danger they run lest the animal spirits should swoon and be suffocated by the tenuity of the air.

(3) The reflection of the rays of the sun in regions near the polar circles is found to be very weak and ineffective in producing heat, insomuch that the Dutch who wintered in Nova Zembla and expected their ship to be freed from the obstructions of the mass of ice which hemmed her in by the beginning of July, were disappointed in their expectation and obliged to take to their boat. Thus the direct rays of the sun seem to have but little power, even on the level ground; nor have the reflex much, unless they are multiplied and combined, which is the case when the sun tends more to the perpendicular, for then the incident rays make acuter angles, so that the lines of the rays are nearer each other; whereas on the contrary, when the sun shines very obliquely, the angles are very obtuse, and thus the lines of rays are at a greater distance from each other. Meanwhile, it should be observed that there may be many operations of the sun, and those too depending on the nature of

heat, which are not proportioned to our touch, so that in respect to us their action does not go so far as to produce sensible warmth, but in respect to some other bodies they have the effect of heat.

(4) Try the following experiment. Take a glass fashioned in a contrary manner to a common burning glass and, placing it between your hand and the rays of the sun, observe whether it diminishes the heat of the sun, as a burning glass increases and strengthens it. For it is evident in the case of optical rays that according as the glass is made thicker or thinner in the middle as compared with the sides, so do the objects seen through it appear more spread or more contracted. Observe therefore whether the same is the case with heat.

(5) Let the experiment be carefully tried, whether by means of the most powerful and best constructed burning glasses, the rays of the moon can be so caught and collected as to produce even the last degree of warmth. But should this degree of warmth prove too subtle and weak to be perceived and apprehended by the touch, recourse must be had to those glasses which indicate the state of the atmosphere in respect to heat and cold. Thus, let the rays of the moon fall through a burning glass on the top of a glass of this kind, and then observe whether there ensues a sinking of the water through warmth.

(6) Let a burning glass also be tried with a heat that does not emit rays or light, as that of iron or stone heated but not ignited, boiling water, and the like; and observe whether there ensue an increase of the heat, as in the case of the sun's rays.

(7) Let a burning glass also be tried with common flame.

(8) Comets (if we are to reckon these too among meteors) are not found to exert a constant or manifest effect in increasing the heat of the season, though it is observed that they are often followed by droughts. Moreover bright beams and pillars and openings in the heavens appear more frequently in winter than in summertime, and chiefly during the intensest cold, but always accompanied by dry weather. Lightning, however, and coruscations and thunder seldom occur in the winter, but about the time of great heat. Falling stars, as they are called, are commonly supposed to consist rather of some bright and lighted viscous substance, than to be of any strong fiery nature. But on this point let further inquiry be made.

(9) There are certain coruscations which give light but do not burn. And these always come without thunder.

(10) Eructations and eruptions of flame are found no less in cold than in warm countries, as in Iceland and Greenland. In cold countries, too, the trees are in many cases more inflammable and more pitchy and resinous than in warm; as the fir, pine, and others. The situations however and the nature of the soil in which eruptions of this kind usually occur have not been carefully enough ascertained to enable us to subjoin a negative to this affirmative instance.

(11) All flame is in all cases more or less warm; nor is there any negative to be subjoined. And yet they say that the *ignis fatuus* (as it is called), which sometimes even settles on a wall, has not much heat, perhaps as much as the flame of spirit of wine, which is mild and soft. But still milder must that flame be which, according to certain grave and trustworthy histories has been seen shining about the head and locks of boys and girls, without at all burning the hair, but softly playing round it. It is also most certain that about a horse, when sweating on the road, there is sometimes seen at night, and in clear weather, a sort of luminous appearance without any manifest heat. And it is a well-known fact, and looked upon as a sort of miracle, that a few years ago a girl's stomacher, on being slightly shaken

or rubbed, emitted sparks, which was caused perhaps by some alum or salts used in the dye, that stood somewhat thick and formed a crust, and were broken by the friction. It is also most certain that all sugar, whether refined or raw, provided only it be somewhat hard, sparkles when broken or scraped with a knife in the dark. In like manner sea and salt water is sometimes found to sparkle by night when struck violently by oars. And in storms, too, at nighttime, the foam of the sea when violently agitated emits sparks, and this sparkling the Spaniards call *Sea Lung*. With regard to the heat of the flame which was called by ancient sailors Castor and Pollux, and by moderns St. Elmo's Fire, no sufficient investigation thereof has been made.

(12) Every body ignited so as to turn to a fiery red, even if unaccompanied by flame, is always hot; neither is there any negative to be subjoined to this affirmative. But that which comes nearest seems to be rotten wood, which shines by night and yet is not found to be hot; and the putrefying scales of fish, which also shine in the dark and yet are not warm to the touch; nor, again, is the body of the glowworm, or of the fly called *Luciola*, found to be warm to the touch….

Thirdly, we must make a presentation to the understanding of instances in which the nature under inquiry is found in different degrees, more or less; which must be done by making a comparison either of its increase and decrease in the same subject, or of its amount in different subjects, as compared one with another. For since the form of a thing is the very thing itself, and the thing differs from the form no otherwise than as the apparent differs from the real, or the external from the internal, or the thing in reference to man from the thing in reference to the universe, it necessarily follows that no nature can be taken as the true form, unless it always decrease when the nature in question decreases, and in like manner always increase when the nature in question increases. This Table therefore I call the *Table of Degrees* or the *Table of Comparison*.

Table of Degrees or Comparison in Heat

I will therefore first speak of those substances which contain no degree at all of heat perceptible to the touch, but seem to have a certain potential heat only, or disposition and preparation for hotness. After that I shall proceed to substances which are hot actually, and to the touch, and to their intensities and degrees.

(1) In solid and tangible bodies we find nothing which is in its nature originally hot. For no stone, metal, sulphur, fossil, wood, water, or carcass of animal is found to be hot. And the hot water in baths seems to be heated by external causes; whether it be by flame or subterraneous fire, such as is thrown up from Etna and many other mountains, or by the conflict of bodies, as heat is caused in the dissolution of iron and tin. There is therefore no degree of heat palpable to the touch in animate substances; but they differ in degree of cold, wood not being equally cold with metal. But this belongs to the Table of Degrees in Cold.

(2) As far, however, as potential heat and aptitude for flame is concerned, there are many inanimate substances found strongly disposed thereto, as sulphur, naphtha, rock oil.

(3) Substances once hot, as horse dung from animal heat, and lime or perhaps ashes and soot from fire, retain some latent remains of their former heat. Hence certain distillations and resolutions of bodies are made by burying them in horse dung, and heat is excited in lime by sprinkling it with water, as already mentioned.

(4) In the vegetable creation we find no plant or part of plant (as gum or pitch) which is

warm to the human touch. But yet, as stated above, green herbs gain warmth by being shut up; and to the internal touch, as the palate or stomach, and even to external parts, after a little time, as in plasters and ointments, some vegetables are perceptibly warm and others cold.

(5) In the parts of animals after death or separation from the body, we find nothing warm to the human touch. Not even horse dung, unless enclosed and buried, retains its heat. But yet all dung seems to have a potential heat, as is seen in the fattening of the land. In like manner carcasses of animals have some such latent and potential heat, insomuch that in burying grounds, where burials take place daily, the earth collects a certain hidden heat which consumes a body newly laid in it much more speedily than pure earth. We are told too that in the East there is discovered a fine soft texture, made of the down of birds, which by an innate force dissolves and melts butter when lightly wrapped in it.

(6) Substances which fatten the soil, as dung of all kinds, chalk, sea sand, salt, and the like, have some disposition to heat.

(7) All putrefaction contains in itself certain elements of a slight heat, though not so much as to be perceived by the touch. For not even those substances which on putrefaction turn to animalculae, as flesh, cheese, etc., feel warm to the touch; no more does rotten wood, which shines in the dark. Heat, however, in putrid substances sometimes betrays itself by foul and powerful odors.

(8) The first degree of heat therefore among those substances which feel hot to the touch, seems to be the heat of animals, which has a pretty great extent in its degrees. For the lowest, as in insects, is hardly perceptible to the touch, but the highest scarcely equals the sun's heat in the hottest countries and seasons, nor is it too great to be borne by the hand. It is said, however, of Constantius, and some others of a very dry constitution and habit of body, that in violent fevers they became so hot as somewhat to burn the hand that touched them….

14. How poor we are in history anyone may see from the foregoing tables, where I not only insert sometimes mere traditions and reports (though never without a note of doubtful credit and authority) in place of history proved and instances certain, but am also frequently forced to use the words "Let trial be made," or "Let it be further inquired."

15. The work and office of these three tables I call the Presentation of Instances to the Understanding. Which presentation having been made, induction itself must be set at work; for the problem is, upon a review of the instances, all and each, to find such a nature as is always present or absent with the given nature, and always increases and decreases with it; and which is, as I have said, a particular case of a more general nature. Now if the mind attempt this affirmatively from the first, as when left to itself it is always wont to do, the result will be fancies and guesses and notions ill defined, and axioms that must be mended every day, unless like the schoolmen we have a mind to fight for what is false; though doubtless these will be better or worse according to the faculties and strength of the understanding which is at work. To God, truly, the Giver and Architect of Forms, and it may be to the angels and higher intelligences, it belongs to have an affirmative knowledge of forms immediately, and from the first contemplation. But this assuredly is more than man can do, to whom it is granted only to proceed at first by negatives, and at last to end in affirmatives after exclusion has been exhausted.

16. We must make, therefore, a complete solution and separation of nature, not indeed by fire, but by the mind, which is a kind of divine fire. The first work, therefore, of true

induction (as far as regards the discovery of forms) is the rejection or exclusion of the several natures which are not found in some instance where the given nature is present, or are found in some instance where the given nature is absent, or are found to increase in some instance when the given nature decreases, or to decrease when the given nature increases. Then indeed after the rejection and exclusion has been duly made, there will remain at the bottom, all light opinions vanishing into smoke, a form affirmative, solid, and true and well defined. This is quickly said; but the way to come at it is winding and intricate. I will endeavor, however, not to overlook any of the points which may help us toward it.

Francis Bacon. "The New Organon." Selections taken from Books 1 and 2. Trans. James Spedding, Robert Leslie Ellis, and Douglas Denon Heath. *The Works* of Francis Bacon. Vol. 8. Boston: Taggard and Thompson, 1863.

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