of what has been, and divine of the new with an imagination preoccupied and coloured by the old; which way of forming opinions is very fallacious; for streams that are drawn from the springheads of nature do not always run in the old channels.

If, for instance, before the invention of ordnance, a man had described the thing by its effects, and said that there was a new invention, by means of which the strongest towers and walls could be shaken and thrown down at a great distance; men would doubtless have begun to think over all the ways of multiplying the force of catapults and mechanical engines by weights and wheels and such machinery for ramming and projecting; but the notion of a fiery blast suddenly and violently expanding and exploding would hardly have entered into any man's imagination or fancy; being a thing to which nothing immediately analogous had been seen, except perhaps in an earthquake or in lightning, which as *magnalia* or marvels of nature, and by man not imitable, would have been immediately rejected.

In the same way, if before the discovery of silk, any one had said there was a kind of thread discovered for the purposes of dress and furniture, which far surpassed the thread of linen or of wool in fineness and at the same time in strength, and also in beauty and softness; men would have begun immediately to think of some silky kind of vegetable, or of the finer hair of some animal, or of the feathers and down of birds; but of a web woven by a tiny worm, and that in such abundance, and renewing itself yearly, they would assuredly never have thought. Nay, if any one had said anything about a worm, he would no doubt have been laughed at as dreaming of a new kind of cobwebs.

So again, if before the discovery of the magnet, any one had said that a certain instrument had been invented by means of which the quarters and points of the heavens could be taken and distinguished with exactness; men would have been carried by their imagination to a variety of conjectures concerning the more exquisite construction of astronomical instruments; but that anything could be discovered agreeing so well in its movements with the heavenly bodies, and yet not a heavenly body itself, but simply a substance of metal or stone, would have been judged altogether incredible. Yet these things and others like them lay for so many ages of the world concealed from men, nor was it by philosophy or the rational arts that they were found out at last, but by accident and occasion; being indeed, as I said, altogether different in kind and as remote as possible from anything that was known before; so that no preconceived notion could possibly have led to the discovery of them.

There is therefore much ground for hoping that there are still laid up in the womb of nature many secrets of excellent use, having no affinity or parallelism with any thing that is now known, but lying entirely out of the beat of the imagination, which have not yet been found out. They too no doubt will some time or other, in the course and revolution of many ages, come to light of themselves, just as the others did; only by the method of which we are now treating they can be speedily and suddenly and simultaneously presented and anticipated.

CX.

But we have also discoveries to show of another kind, which prove that noble inventions may be lying at our very feet, and yet mankind may step over without seeing them. For however the discovery of gunpowder, of silk, of the magnet, of sugar, of paper, or the like, may seem to depend on certain properties of things themselves and nature, there is at any rate nothing in the art of printing which is not plain and obvious. Nevertheless for want of observing that although it is more difficult to arrange types of letters than to write letters by the motion of the hand, there is yet this difference between the two, that types once arranged serve for innumerable impressions, but letters written with the hand for a single copy only; or perhaps again for want of observing that ink can be so thickened as to colour without running (particularly when the letters face upwards and the impression is made from above)—for want, I say, of observing these things, men went for so many ages without this most beautiful discovery, which is of so much service in the propagation of knowledge.

But such is the infelicity and unhappy disposition of the human mind in this course of invention, that it first distrusts and then despises itself: first will not believe that any such thing can be found out; and when it is found out, cannot understand how the world should have missed it so long. And this very thing may be justly taken as an argument of hope; namely, that there is a great mass of inventions still remaining, which not only by means of operations that are yet to be discovered, but also through the transferring, comparing, and applying of those already known, by the help of that Learned Experience of which I spoke, may be deduced and brought to light.

CXI.

There is another ground of hope that must not be omitted. Let men but think over their infinite expenditure of understanding, time, and means on matters and pursuits of far less use and value; whereof if but a small part were directed to sound and solid studies, there is no difficulty that might not be overcome. This I thought good to add, because I plainly confess that a collection of history natural and experimental, such as I conceive it and as it ought to be, is a great, I may say a royal work, and of much labour and expense.

CXII.

Meantime, let no man be alarmed at the multitude of particulars, but let this rather encourage him to hope. For the particular phenomena of art and nature are but a handful to the inventions of the wit, when disjoined and separated from the evidence of things. Moreover this road has an issue in the open ground and not far off; the other has no issue at all, but endless entanglement. For men hitherto have made but short stay with experience, but passing her lightly by, have wasted an infinity of time on meditations and glosses of the wit. But if some one were by that could answer our questions and tell us in each case what the fact in nature is, the discovery of all causes and sciences would be but the work of a few years.

CXIII.

Moreover I think that men may take some hope from my own example. And this I say not by way of boasting, but because it is useful to say it. If there be any that despond, let them look at me, that being of all men of my time the most busied in affairs of state, and a man of health not very strong (whereby much time is lost), and in this course altogether a pioneer, following in no man's track, nor sharing these counsels with any one, have nevertheless by resolutely entering on the true road, and submitting my mind to Things, advanced these matters, as I suppose, some little way. And then let them consider what may be expected (after the way has been thus indicated) from men abounding in leisure, and from association of labours, and from successions of ages: the rather because it is not a way over which only one man can pass at a time (as is the case with that of reasoning), but one in which the labours and industries of men (especially as regards the collecting of experience), may with the best effect be first distributed and then combined. For then only will men begin to know their strength when instead of great numbers doing all the same things, one shall take charge of one thing and another of another.

CXIV.

Lastly, even if the breath of hope which blows on us from that New Continent were fainter than it is and harder to perceive [60]; yet the trial (if we would not bear a spirit altogether abject) must by all means be made. For there is no comparison between that which we may lose by not trying and by not succeeding; since 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 as it is, it appears to me from what has been said, and also from what has been left unsaid, that

[60] Bacon refers to what Peter Martyr Anghiera has related, that Columbus, observing the west-winds which blow at certain times of the year on the coast of Portugal, came to the conclusion that there must be land to generate them.

there is hope enough and to spare, not only to make a bold man try, but also to make a sober-minded and wise man believe.

CXV.

Concerning the grounds then for putting away despair, which has been one of the most powerful causes of delay and hindrance to the progress of knowledge, I have now spoken. And this also concludes what I had to say touching the *signs* and *causes* of the errors, sluggishness, and ignorance which have prevailed; especially since the more subtle causes, which do not fall under popular judgment and observation, must be referred to what has been said on the Idols of the human mind.

And here likewise should close that part of my Instauration, which is devoted to pulling down: which part is performed by three refutations; first, by the refutation of the *natural human reason*, left to itself; secondly, by the refutation of the *demonstrations*; and thirdly, by the refutation of the *theories*, or the received systems of philosophy and doctrine. And the refutation of these has been such, as alone it could be: that is to say, by signs and the evidence of causes since no other kind of confutation was open to me, differing as I do from others; both on first principles and on rules of demonstration.

It is time therefore to proceed to the art itself and rule of interpreting nature; still however there remains something to be premised. For whereas in this first book of aphorisms I proposed to prepare men's minds as well for understanding as for receiving what is to follow; now that I have purged and swept and levelled the floor of the mind, it remains that I place the mind in a good position and as it were in a favourable aspect towards what I have to lay before it. For in a new matter, it is not only the strong preoccupation of some old opinion that tends to create a prejudice, but also a false preconception or prefiguration of the new thing which is presented. I will endeavour therefore to impart sound and true opinions as to the things I propose, although they are to serve only for the time, and by way of interest (so to speak), till the thing itself, which is the principal, be fully known.

CXVI.

First, then, I must request men not to suppose that after the fashion of ancient Greeks, and of certain moderns, as Telesius, Patricius, Severinus [61], I wish to found a new sect in philosophy. For this is not what I am about; nor do I think that it matters much to the fortunes of men what abstract notions one may entertain concerning nature and the principles of things; and no doubt many old theories of this kind can be revived and many new ones introduced; just as many theories of the heavens may be supposed, which agree well enough with the phenomena and yet differ with each other.

But for my part I do not trouble myself with any such speculative and withal unprofitable matters. My purpose, on the contrary, is to try whether I cannot in very fact lay more firmly the foundations, and extend more widely the limits, of the power and greatness of man. And although on some special subjects and in an incomplete form I am in possession of results which I take to be far more true and more certain and withal more fruitful than those now received, (and these I have collected into the fifth part of my Instauration), yet I have no entire or universal theory to propound. For it does not seem that the time is come for such an attempt. Neither can I hope to live to complete the sixth part of the Instauration (which is destined for the philosophy discovered by the legitimate interpretation of nature), but hold it enough if in the intermediate business I bear myself soberly and profitably, sowing in the meantime for future ages the seeds of a purer truth, and performing my part towards the commencement of the great undertaking.

[61] See *De Aug.* iv. 3. for a rather fuller mention of these philosophers, and the note upon the passage. See also, for Telesius, the preface to *De Principiis atque Originibus*; for Patricius, the *Descriptio Globi intellectualis*; for Severinus, the *Temporis Partus Masculus*.—*J.S.*

CXVII.

And as I do not seek to found a school, so neither do I hold out offers or promises of particular works. It may be thought indeed, that I who make such frequent mention of works and refer everything to that end, should produce some myself by way of earnest. But my course and method, as I have often clearly stated and would wish to state again, is this,—not to extract works from works or experiments from experiments (as an empiric), but from works and experiments to extract causes and axioms, and again from those causes and axioms new works and experiments, as a legitimate interpreter of nature. And although in my tables of discovery (which compose the fourth part of the Instauration), and also in the examples of particulars (which I have adduced in the second part), and moreover in my observations on the history (which I have drawn out in the third part), any reader of even moderate sagacity and intelligence will everywhere observe indications and outlines of many noble works; still I candidly confess that the natural history which I now have, whether collected from books or from my own investigations, is neither sufficiently copious nor verified with sufficient accuracy to serve the purposes of legitimate interpretation.

Accordingly, if there be any one more apt and better prepared for mechanical pursuits, and sagacious in hunting out works by the mere dealing with experiment, let him by all means use his industry to gather from my history and tables many things by the way, and apply them to the production of works, which may serve as interest until the principal be forthcoming. But for myself, aiming as I do at greater things, I condemn all unseasonable and premature tarrying over such things as these; being (as I often say) like Atalanta's balls. For I do not run off like a child after golden apples, but stake all on the victory of art over nature in the race; nor do I make haste to mow down the moss or the corn in blade, but wait for the harvest in its due season.

CXVIII.

There will be found, no doubt, when my history and tables of discovery are read, some things in the experiments themselves that are not quite certain, or perhaps that are quite false; which may make a man think that the foundations and principles upon which my discoveries rest are false and doubtful. But this is of no consequence; for such things must needs happen at first. It is only like the occurrence in a written or printed page of a letter or two mistaken or misplaced; which does not much hinder the reader, because such errors are easily corrected by the sense. So likewise may there occur in my natural history many experiments which are mistaken and falsely set down, and yet they will presently by the discovery of causes and axioms be easily expunged and rejected. It is nevertheless true that if the mistakes in natural history and experiments are important, frequent, and continual, they cannot possibly be corrected or amended by any felicity of wit or art. And therefore, if in my natural history, which has been collected and tested with so much diligence, severity, and I may say religious care, there still lurk at intervals certain falsities or errors in the particulars,—what is to be said of common natural history, which in comparison with mine is so negligent and inexact? and what of the philosophy and sciences built on such a sand (or rather quicksand)? Let no man therefore trouble himself for this.

CXIX.

There will be met with also in my history and experiments many things which are trivial and commonly known; many which are mean and low; many, lastly, which are too subtle and merely speculative, and that seem to be of no use; which kind of things may possibly avert and alienate men's interests.

And first for those things which seem common; let men bear in mind that hitherto they have been accustomed to do no more than refer and adapt the causes of things which rarely happen to such as happen frequently; while of those which happen frequently they never ask the cause, but take them as they are for granted. And therefore they do not investigate the causes of weight, of the rotation of heavenly bodies, of heat, cold, light, hardness, softness, rarity,

density, liquidity, solidity, animation, inanimation, similarity, dissimilarity, organization, and the like ; but admitting these as self-evident and obvious, they dispute and decide on other things of less frequent and familiar occurrence.

But I, who am well aware that no judgment can be passed on uncommon or remarkable things, much less anything new brought to light, unless the causes of common things, and the causes of those causes, be first duly examined and found out, am of necessity compelled to admit the commonest things into my history. Nay, in my judgment philosophy has been hindered by nothing more than this,—that things of familiar and frequent occurrence do not arrest and detain the thoughts of men, but are received in passing without any inquiry into their causes ; insomuch that information concerning things which are not known is not oftener wanted than attention concerning things which are.

CXX.

And for things that are mean or even filthy,—things which (as Pliny says) must be introduced with an apology [62],—such things, no less than the most splendid and costly, must be admitted into natural history. Nor is natural history polluted thereby ; for the sun enters the sewer no less than the palace, yet takes no pollution. And for myself, I am not raising a capitol or pyramid to the pride of man, but laying a foundation in the human understanding for a holy temple after the model of the world. That model therefore I follow. For whatever deserves to exist deserves also to be known, for knowledge is the image of existence ; and things mean and splendid exist alike. Moreover as from certain putrid substances—musk, for instance, and civet—the sweetest odours are sometimes generated, so too from mean and sordid instances there sometimes emanates excellent light and information. But enough and more than enough of this ; such fastidiousness being merely childish and effeminate.

CXXI.

But there is another objection which must be more carefully looked to : namely, that there are many things in this History which to common apprehension, or indeed to any understanding accustomed to the present system, will seem to be curiously and unprofitably subtle. Upon this point therefore above all I must say again what I have said already,—that at first and for a time I am seeking for experiments of light, not for experiments of fruit ; following therein, as I have often said, the example of the divine creation ; which on the first day produced light only, and assigned to it alone one entire day, nor mixed up with it on that day any material work.

To suppose therefore that things like these are of no use is the same as to suppose that light is of no use, because it is not a thing solid or material. And the truth is that the knowledge of simple natures well examined and defined is as light ; it gives entrance to all the secrets of nature's workshop, and virtually includes and draws after it whole bands and troops of works, and opens to us the sources of the noblest axioms ; and yet in itself it is of no great use. So also the letters of the alphabet in themselves and apart have no use or meaning, yet they are the subject-matter for the composition and apparatus of all discourse. So again the seeds of things are of much latent virtue, and yet of no use except in their development. And the scattered rays of light itself, until they are made to converge, can impart none of their benefit.

But if objection be taken to speculative subtleties, what is to be said of the schoolmen, who have indulged in subtleties to such excess ? in subtleties too that were spent on words, or at any rate on popular notions (which is much the same thing), not on facts of nature ; and such as were useless not only in their origin but also in their consequences ; and not like those I speak of, useless indeed for the present, but promising infinite utility hereafter. But let men be assured of this, that all subtlety of disputation and discourse, if not applied till after axioms are discovered, is out of season and preposterous ; and that the true and proper or at any rate the chief time for subtlety is in weighing experience and in found-

[62] Plin. *Hist. Nat.* i. ad init. Compare also Aristotle, *De Part. Animal.* i. 5.

ing axioms thereon ; for that other subtlety, though it grasps and snatches at nature, yet can never take hold of her. Certainly what is said of opportunity or fortune is most true of nature ; she has a lock in front, but is bald behind.

Lastly, concerning the disdain to receive into natural history things either common, or mean, or over-subtle and in their original condition useless, the answer of the poor woman to the haughty prince [63], who had rejected her petition as an unworthy thing and beneath his dignity, may be taken for an oracle,— " Then leave off being king ". For most certain it is that he who will not attend to things like these, as being too paltry and minute, can neither win the kingdom of nature nor govern it.

CXXII.

It may be thought also a strange and harsh thing that we should at once and with one blow set aside all sciences and all authors ; and that too without calling in any of the ancients to our aid and support, but relying on our own strength.

And I know that if I had chosen to deal less sincerely, I might easily have found authority for my suggestions by referring them either to the old times before the Greeks (when natural science was perhaps more flourishing, though it made less noise, not yet having passed into the pipes and trumpets of the Greeks), or even, in part at least, to some of the Greeks themselves ; and so gained for them both support and honour ; as men of no family devise for themselves by the good help of genealogies the nobility of a descent from some ancient stock. But for my part, relying on the evidence and truth of things, I reject all forms of fiction and imposture ; nor do I think that it matters any more to the business in hand, whether the discoveries that shall now be made were long ago known to the ancients, and have their settings and their risings according to the vicissitude of things and course of ages, than it matters to mankind whether the new world be that island of Atlantis with which the ancients were acquainted, or now discovered for the first time. For new discoveries must be sought from the light of nature, not fetched back out of the darkness of antiquity.

And as for the universality of the censure, certainly if the matter be truly considered, such a censure is not only more probable but more modest too, than a partial one would be. For if the errors had not been rooted in primary notions, there must have been some true discoveries to correct the false. But the errors being fundamental, and not so much of false judgment as of inattention and oversight, it is no wonder that men have not obtained what they have not tried for, nor reached a mark which they never set up, nor finished a course which they never entered on or kept.

And as for the presumption implied in it ; certainly if a man undertakes by steadiness of hand and power of eye to describe a straighter line or more perfect circle than any one else, he challenges a comparison of abilities ; but if he only says that he with the help of a rule or a pair of compasses can draw a straighter line or a more perfect circle than any one else can by eye and hand alone, he makes no great boast. And this remark, be it observed, applies not merely to this first and inceptive attempt of mine, but to all that shall take the work in hand hereafter. For my way of discovering sciences goes far to level men's wits, and leaves but little to individual excellence ; because it performs everything by the surest rules and demonstrations. And therefore attribute my part in all this, as I have often said, rather to good luck than to ability, and account it a birth of time rather than of wit. For certainly chance has something to do with men's thoughts, as well as with their works and deeds.

CXXIII.

I may say then of myself that which one said in jest (since it marks the distinction so truly), " It cannot be that we should think alike, when one drinks water and the other drinks wine " [64]. Now other men, as well in ancient as in modern times, have in the matter of sciences drunk a crude liquor like water, either flowing spontaneously from the understanding, or drawn up by logic, as

[63] [Philip of Macedon. See Plutarch, *Apophthegmata*.—Ed.]

[64] [Said by Philocrates of Demosthenes. Demos. *De Falsa Legatione*.—Ed.]

by wheels from a well. Whereas I pledge mankind in a liquor strained from countless grapes, from grapes ripe and fully seasoned, collected in clusters, and gathered, and then squeezed in the press, and finally purified and clarified in the vat. And therefore it is no wonder if they and I do not think alike.

CXXIV.

Again, it will be thought, no doubt, that the goal and mark of knowledge which I myself set up (the very point which I object to in others) is not the true or the best; for that the contemplation of truth is a thing worthier and loftier than all utility and magnitude of works; and that this long and anxious dwelling with experience and matter and the fluctuations of individual things, drags down the mind to earth, or rather sinks it to a very Tartarus of turmoil and confusion; removing and withdrawing it from the serene tranquillity of abstract wisdom, a condition far more heavenly. Now to this I readily assent; and indeed this which they point at as so much to be preferred, is the very thing of all others which I am about. For I am building in the human understanding a true model of the world, such as it is in fact, not such as a man's own reason would have it to be; a thing which cannot be done without a very diligent dissection and anatomy of the world. But I say that those foolish and apish images of worlds which the fancies of men have created in philosophical systems, must be utterly scattered to the winds. Be it known then how vast a difference there is (as I said above) between the Idols of the human mind and the Ideas of the divine. The former are nothing more than arbitrary abstractions; the latter are the creator's own stamp upon creation, impressed and defined in matter by true and exquisite lines. Truth therefore and utility are here the very same things [65]: and works themselves are of greater value as pledges of truth than as contributing to the comforts of life.

CXXV.

It may be thought again that I am but doing what has been done before; that the ancients themselves took the same course which I am now taking; and that it is likely therefore that I too, after all this stir and striving, shall come at last to some one of those systems which prevailed in ancient times. For the ancients too, it will be said, provided at the outset of their speculations a great store and abundance of examples and particulars, digested the same into note books under heads and titles, from them completed their systems and arts, and afterwards, when they understood the matter, published them to the world,—adding a few examples here and there for proof and illustration; but thought it superfluous and inconvenient to publish their notes and minutes and digests or particulars; and therefore did as builders do,—after the house was built they removed the scaffolding and ladders out of sight. And so no doubt they did. But this objection (or scruple rather) will be easily answered by any one who has not quite forgotten what I have said above. For the form of inquiry and discovery that was in use among the ancients is by themselves professed, and appears on the very face of their writings. And that form was simply this. From a few examples and particulars (with the addition of common notions and perhaps of some portion of the received opinions which have been most popular) they flew at once to the most general conclusions, or first principles of science: taking the truth of these as fixed and immovable, they proceeded by means of intermediate propositions to educe and prove from them the inferior conclusions; and out of these they framed the art. After that, if any new particulars and examples repugnant to their dogmas were mooted and adduced, either they subtly moulded them into their system by distinctions or explanations of their rules, or else coarsely got rid of them by exceptions; while to such particulars as were not repugnant they laboured to assign causes in conformity with those of their principles. But this was not the natural history and experience that was wanted; far from it; and besides, that flying off to the highest generalities ruined all.

[65] *Ipsissimæ res.* I think this must have been Bacon's meaning, though not a meaning which the word can properly bear.—*J. S.*

CXXVI.

It will also be thought that by forbidding men to pronounce and to set down principles as established until they have duly arrived through the intermediate steps at the highest generalities, I maintain a sort of suspension of the judgment and bring it to what the Greeks call *Acatalepsia*,—a denial of the capacity of the mind to comprehend truth. But in reality that which I meditate and propound is not *Acatalepsia*, but *Eucatalepsia* ; not denial of the capacity to understand, but provision for the understanding truly ; for I do not take away authority from the senses, but supply them with helps ; I do not slight the understanding, but govern it. And better surely it is that we should know all we need to know, and yet think our knowledge imperfect, than that we should think our knowledge perfect, and yet not know anything we need to know.

CXXVII.

It may also be asked (in the way of doubt rather than objection) whether I speak of natural philosophy only, or whether I mean that the other sciences, logic, ethics, and politics, should be carried on by this method. Now I certainly mean what I have said to be understood of them all ; and as the common logic, which governs by the syllogism, extends not only to natural but to all sciences ; so does mine also, which proceeds by induction, embrace everything. For I form a history and tables of discovery for anger, fear, shame, and the like ; for matters political ; and again for the mental operations of memory, composition and division [66], judgment and the rest ; not less than for heat and cold, or light, or vegetation, or the like [67]. But nevertheless since my method of interpretation, after the history has been prepared and duly arranged, regards not the working and discourse of the mind only (as the common logic does) but the nature of things also, I supply the mind with such rules and guidance that it may in every case apply itself aptly to the nature of things. And therefore I deliver many and diverse precepts in the doctrine of Interpretation, which in some measure modify the method of invention according to the quality and condition of the subject of the inquiry.

CXXVIII.

On one point not even a doubt ought to be entertained ; namely, whether I desire to pull down and destroy the philosophy and arts and sciences which are at present in use. So far from that, I am most glad to see them used, cultivated, and honoured. There is no reason why the arts which are now in fashion should not continue to supply matter for disputation and ornaments for discourse, to be employed for the convenience of professors and men of business ; to be in short like current coin, which passes among men by consent. Nay I frankly declare that what I am introducing will be but little fitted for such purposes as these, since it cannot be brought down to common apprehension, save by effects and works only. But how sincere I am in my professions of affection and good will towards the received sciences, my published writings, especially the books on the Advancement of Learning, sufficiently show ; and therefore I will not attempt to prove it further by words. Meanwhile I give constant and distinct warning that by the methods now in use neither can any great progress be made in the doctrines and contemplative part of sciences, nor can they be carried out to any magnitude of works.

[66] [Mr. Ellis suggested that the meaning here may be "synthesis and analysis". Professor Fowler, however, has pointed out that what is meant is "affirmation and negation", following the terminology of Aristotle.—ED.]

[67] This passage is important because it shows that Bacon proposed to apply his method to mental phenomena ; which is in itself a sufficient refutation of M. Cousin's interpretation of the passage in which, when censuring the writings of the schoolmen, he compares them to the self-evolved web of the spider. I have elsewhere spoken more at length of this passage. [See preface, p. 230.]

CXXIX.

It remains for me to say a few words touching the excellency of the end in view. Had they been uttered earlier, they might have seemed like idle wishes; but now that hopes have been raised and unfair prejudices removed, they may perhaps have greater weight. Also if I had finished all myself, and had no occasion to call in others to help and take part in the work, I should even now have abstained from such language, lest it might be taken as a proclamation of my own deserts. But since I want to quicken the industry and rouse and kindle the zeal of others, it is fitting that I put men in mind of some things.

In the first place then, the introduction of famous discoveries appears to hold by far the first place among human actions; and this was the judgment of the former ages. For to the authors of inventions they awarded divine honours; while to those who did good service in the state (such as founders of cities and empires, legislators, saviours of their country from long endured evils, quellers of tyrannies, and the like) they decreed no higher honours than heroic. And certainly if a man rightly compare the two, he will find that this judgment of antiquity was just. For the benefits of discoveries may extend to the whole race of man, civil benefits only to particular places; the latter last not beyond a few ages, the former through all time. Moreover the reformation of a state in civil matters is seldom brought in without violence and confusion; but discoveries carry blessings with them, and confer benefits without causing harm or sorrow to any.

Again, discoveries are as it were new creations, and imitations of God's works; as well sang the poet:—

> "To man's frail race great Athens long ago
> First gave the seed whence waving harvests grow,
> And *re-created* all our life below" [68].

And it appears worthy of remark in Solomon, that though mighty in empire and in gold; in the magnificence of his works, his court, his household, and his fleet; in the lustre of his name and the worship of mankind; yet he took none of these to glory in, but pronounced that "The glory of God is to conceal a thing; the glory of the king to search it out" [69].

Again, let a man only consider what a difference there is between the life of men in the most civilized province of Europe, and in the wildest and most barbarous districts of New India; he will feel it be great enough to justify the saying that "man is a god to man", not only in regard of aid and benefit, but also by a comparison of condition. And this difference comes not from soil, not from climate, not from race, but from the arts.

Again, it is well to observe the force and virtue and consequences of discoveries; and these are to be seen nowhere more conspicuously than in those three which were unknown to the ancients, and of which the origin, though recent, is obscure and inglorious; namely, printing, gunpowder, and the magnet. For these three have changed the whole face and state of things throughout the world; the first in literature, the second in warfare, the third in navigation; whence have followed innumerable changes; insomuch that no empire, no sect, no star seems to have exerted greater power and influence in human affairs than these mechanical discoveries.

Further, it will not be amiss to distinguish the three kinds and as it were grades of ambition in mankind. The first is of those who desire to extend their own power in their native country; which kind is vulgar and degenerate. The second is of those who labour to extend the power of their country and its dominion among men. This certainly has more dignity, though not less covetousness. But if a man endeavour to establish and extend the power and dominion of the human race itself over the universe, his ambition (if ambition it can be called) is without doubt both a more wholesome thing and a more noble than the other two. Now the empire of man over things depends wholly on the arts and sciences. For we cannot command nature except by obeying her.

[68] Lucretius, vi. 1-3.

[69] Prov. xxv. 2.

Again, if men have thought so much of some one particular discovery as to regard him as more than man who has been able by some benefit to make the whole human race his debtor, how much higher a thing to discover that by means of which all things else shall be discovered with ease! And yet (to speak the whole truth), as the uses of light are infinite, in enabling us to walk, to ply our arts, to read, to recognise one another; and nevertheless the very beholding of the light is itself a more excellent and a fairer thing than all the uses of it;—so assuredly the very contemplation of things, as they are, without superstition or imposture, error or confusion, is in itself more worthy than all the fruit of inventions.

Lastly, if the debasement of arts and sciences to purposes of wickedness, luxury, and the like, be made a ground of objection, let no one be moved thereby. For the same may be said of all earthly goods; of wit, courage, strength, beauty, wealth, light itself, and the rest. Only let the human race recover that right over nature which belongs to it by divine bequest, and let power be given it; the exercise thereof will be governed by sound reason and true religion.

CXXX.

And now it is time for me to propound the art itself of interpreting nature; in which, although I conceive that I have given true and most useful precepts, yet I do not say either that it is absolutely necessary (as if nothing could be done without it) or that it is perfect. For I am of opinion that if men had ready at hand a just history of nature and experience, and laboured diligently thereon; and if they could bind themselves to two rules,—the first, to lay aside received opinions and notions; and the second, to refrain the mind for a time from the highest generalisations, and those next to them,—they would be able by the native and genuine force of the mind, without any other art, to fall into my form of interpretation. For interpretation is the true and natural work of the mind when freed from impediments [70]. It is true however that by my precepts everything will be in more readiness, and much more sure.

Nor again do I mean to say that no improvement can be made upon these. On the contrary, I that regard the mind not only in its own faculties, but in its connection with things, must needs hold that the art of discovery may advance as discoveries advance.

[70] Compare *Valerius Terminus*, ch. 22 :—"That it is true that interpretation is the very natural and direct intention, action, and progression of the understanding, delivered from impediments; and that all anticipation is but a deflexion or declination by accident". Also *Adv. of Learn.* (2d book) :—"For he that shall attentively observe how the mind doth gather this excellent dew of knowledge, like unto that which the poet speaketh of, *Aërii mellis cœlestia dona*, distilling and contriving it out of particulars natural and artificial, as the flowers of the field and garden, shall find that the mind of herself by nature doth manage and act an induction much better than they describe it".—*J. S.*

THE SECOND BOOK OF APHORISMS CONCERNING THE INTERPRETATION OF NATURE AND THE KINGDOM OF MAN.

APHORISM

I.

ON a given body to generate and superinduce a new nature or new natures, is the work and aim of Human Power. Of a given nature to discover the form, or true specific difference, or nature-engendering nature [1], or source of emanation (for these are the terms which come nearest to a description of the thing), is the work and aim of Human Knowledge [2]. Subordinate to these primary works are two others that are secondary and of inferior mark; to the former, the transformation of concrete bodies, so far as this is possible [3]; to the latter, the discovery, in every case of generation and motion, of the *latent process* carried on from the manifest efficient and the manifest material to the form which is engendered; and in like manner the discovery of the *latent configuration* of bodies at rest and not in motion.

II.

In what an ill condition human knowledge is at the present time, is apparent even from the commonly received maxims. It is a correct position that "true knowledge is knowledge by causes." And causes again are not improperly distributed into four kinds; the material, the formal, the efficient, and the final. But of these the final cause rather corrupts than advances the sciences, except such as have to do with human action. The discovery of the formal is despaired of. The efficient and the material (as they are investigated and received, that is, as remote causes, without reference to the latent process leading to the form)

[1] This is the only passage in which I have met with the phrase *natura naturans* used as it is here. With the later schoolmen, as with Spinoza, it denotes God considered as the *causa immanens* of the universe, and therefore, according to the latter at least, not hypostatically distinct from it. (On the Pantheistic tendency occasionally perceptible among the schoolmen, see Neander's Essay on Scotus Erigena in the *Berlin Memoirs*.) Bacon applies it to the Form, considered as the *causa immanens* of the properties of the body. I regret not having been able to trace the history of this remarkable phrase. It does not occur, I think, in St. Thomas Aquinas, though I have met with it in an index to his *Summa*; the passage referred to containing a quotation from St. Augustine, in which the latter speaks of "ea natura quæ creavit omnes cæteras instituitque naturas". (*V.* St. Aug., *De Trin.* xiv. 9.) Neither does it occur, so far as I am aware, where we might have expected it, in the *De Divisione Naturæ* of Scotus Erigena. Vossius, *De Vitiis Latini Sermonis*, notices its use among the schoolmen, but gives no particular reference. [The phrase in question *does* occur in Thomas Aquinas;—"Etiam Deus a quibusdam dicitur. *natura naturans*" (*Summa: Prima Secundae*, Quæst. 85, art. 6). And see Hauréau, *Histoire de la philosophie scolastique*, 1872–80, i. 189, for a trace of the idea in John Scotus and others in the ninth century.—ED.]

[2] See General Preface, § 7, p. 15.

[3] The *possibility* of transmutation, long and strenuously denied, though certainly on no sufficient grounds, is now generally admitted. "There was a time when this fundamental doctrine of the alchemists was opposed to known analogies. It is now no longer so opposed to them, only some stages beyond their present development."—Faraday, *Lectures on Non-Metallic Elements*, p. 106.

are but slight and superficial, and contribute little, if anything, to true and active science. Nor have I forgotten that in a former passage I noted and corrected as an error of the human mind the opinion that Forms give existence. For though in nature nothing really exists beside individual bodies, performing pure individual acts according to a fixed law, yet in philosophy this very law, and the investigation, discovery, and explanation of it, is the foundation as well of knowledge as of operation. And it is this law, with its clauses, that I mean when I speak of *Forms ;* a name which I the rather adopt because it has grown into use and become familiar.

III.

If a man be acquainted with the cause of any nature (as whiteness or heat) in certain subjects only, his knowledge is imperfect ; and if he be able to superinduce an effect on certain substances only (of those susceptible of such effect), his power is in like manner imperfect. Now if a man's knowledge be confined to the efficient and material causes (which are unstable causes, and merely vehicles, or causes which convey the form in certain cases) he may arrive at new discoveries in reference to substances in some degree similar to one another, and selected beforehand ; but he does not touch the deeper boundaries of things. But whosoever is acquainted with Forms, embraces the unity of nature in substances the most unlike ; and is able therefore to detect and bring to light things never yet done, and such as neither the vicissitudes of nature, nor industry in experimenting, nor accident itself, would ever have brought into act, and which would never have occurred to the thought of man. From the discovery of Forms therefore results truth in speculation and freedom in operation.

IV.

Although the roads to human power and to human knowledge lie close together, and are nearly the same, nevertheless on account of the pernicious and inveterate habit of dwelling on abstractions, it is safer to begin and raise the sciences from those foundations which have relation to practice, and to let the active part itself be as the seal which prints and determines the contemplative counterpart. We must therefore consider, if a man wanted to generate and superinduce any nature upon a given body, what kind of rule or direction or guidance he would most wish for, and express the same in the simplest and least abstruse language. For instance, if a man wishes to superinduce upon silver the yellow colour of gold or an increase of weight (observing the laws of matter), or transparency on an opaque stone, or tenacity on glass, or vegetation on some substance that is not vegetable,—we must consider, I say, what kind of rule or guidance he would most desire. And in the first place, he will undoubtedly wish to be directed to something which will not deceive him in the result, nor fail him in the trial. Secondly, he will wish for such a rule as shall not tie him down to certain means and particular modes of operation. For perhaps he may not have those means, nor be able conveniently to procure them. And if there be other means and other methods for producing the required nature (beside the one prescribed) these may perhaps be within his reach ; and yet he shall be excluded by the narrowness of the rule, and get no good from them. Thirdly, he will desire something to be shown him, which is not as difficult as the thing proposed to be done, but comes nearer to practice.

For a true and perfect rule of operation then the direction will be *that it be certain, free, and disposing or leading to action.* And this is the same thing with the discovery of the true Form. For the Form of a nature is such, that given the Form the nature infallibly follows. Therefore it is always present when the nature is present, and universally implies it, and is constantly inherent in it. Again, the Form is such, that if it be taken away the nature infallibly vanishes. Therefore it is always absent when the nature is absent, and implies its absence, and inheres in nothing else. Lastly, the true Form is such that it deduces the given nature from some source of being which is inherent in more natures, and which is better known in the natural order of things than the Form itself. For a true and perfect axiom of knowledge then the direction and precept will be,

that another nature be discovered which is convertible with the given nature, and yet is a limitation of a more general nature, as of a true and real genus [4]. Now these two directions, the one active the other contemplative, are one and the same thing; and what in operation is most useful, that in knowledge is most true.

V.

The rule or axiom for the transformation of bodies is of two kinds. The first regards a body as a troop or collection of simple natures. In gold, for example, the following properties meet. It is yellow in colour; heavy up to a certain weight; malleable or ductile to a certain degree of extension; it is not volatile, and loses none of its substance by the action of fire; it turns into a liquid with a certain degree of fluidity; it is separated and dissolved by particular means; and so on for the other natures which meet in gold. This kind of axiom, therefore, deduces the thing from the forms of simple natures. For he who knows the forms of yellow, weight, ductility, fixity, fluidity, solution, and so on, and the methods for superinducing them, and their gradations and modes, will make it his care to have them joined together in some body, whence may follow the transformation of that body into gold [5]. And this kind of operation pertains to the first kind of action. For the principle of generating some one simple nature is the same as that of generating many; only that a man is more fettered and tied down in operation, if more are required, by reason of the difficulty of combining into one so many natures; which do not readily meet, except in the beaten and ordinary paths of nature. It must be said however that this mode of operation (which looks to simple natures though in a compound body) proceeds from what in nature is constant and eternal and universal, and opens broad roads to human power, such as (in the present state of things) human thought can scarcely comprehend or anticipate.

The second kind of axiom, which is concerned with the discovery of the *latent process*, proceeds not by simple natures, but by compound bodies, as they are found in nature in its ordinary course. As, for instance, when inquiry is made, from what beginnings, and by what method and by what process, gold or any other metal or stone is generated, from its first menstrua and rudiments up to the perfect mineral; or in like manner by what process herbs are generated, from

[4] Let us adopt, for distinctness of expression, the theory commonly known as Boscovich's,—a theory which forms the basis of the ordinary mathematical theories of light, of heat, and of electricity. This theory supposes all bodies to be constituted of inextended atoms or centres of force, each of which attracts or repels and is attracted or repelled by all the rest. All the phenomena of nature are thus ascribed to mechanical forces, and all the differences which can be conceived to exist between two bodies,—gold say, and silver,—can only arise either from the different configuration of the centres of force, or from the different law by which they act on one another.

Assuming the truth of this theory, the question, why are some bodies transparent and others not so—in other words, what is the essential cause of transparency, which is precisely what Bacon would call the form of transparency,—is to be answered by saying that a certain configuration of the centres of force, combined with the existence of a certain law of force, constitutes such a system that the vibrations of the luminiferous ether pass through it. What this configuration or this law may be, is a question which the present state of mathematical physics does not enable us to answer: but there is no reason *a priori* why in time to come it may not receive a complete solution. If it does we shall then have arrived at a knowledge, on Boscovich's theory, of the form of transparency. Those who are acquainted with the recent progress of physical science know that questions of this kind, so far from being rejected as the questions of a mere dreamer, are thought to be of the highest interest and importance, and that no inconsiderable advance has already been made towards the solution of some at least among them.

[5] "On pourroit trouver le moyen de contrefaire l'or en sorte qu'il satisferoit à toutes les épreuves qu'on en a jusqu'ici; mais on pourroit aussi découvrir alors une nouvelle manière d'essai, qui donneroit le moyen de distinguer l'or naturel de cet or fait par artifice . . . nous pourrions avoir une définition plus parfaite de l'or que nous n'en avons présentement."—Leibnitz, *Nouv. Ess. sur l'Entendement*, c. 2.

the first concretion of juices in the ground or from seeds up to the formed plant, with all the successive motions and diverse and continued efforts of nature. So also in the inquiry concerning the process of development in the generation of animals, from coition to birth ; and in like manner of other bodies.

It is not however only to the generations of bodies that this investigation extends, but also to other motions and operations of nature. As, for instance, when inquiry is made concerning the whole course and continued action of nutrition, from the first reception of the food to its complete assimilation ; or again, concerning the voluntary motion of animals, from the first impression on the imagination and the continued efforts of the spirit up to the bendings and movements of the limbs ; or concerning the motion of the tongue and lips and other instruments, and the changes through which it passes till it comes to the utterance of articulate sounds. For these inquiries also relate to natures concrete or combined into one structure, and have regard to what may be called particular and special habits of nature, not to her fundamental and universal laws which constitute Forms. And yet it must be confessed that this plan appears to be readier and to lie nearer at hand and to give more ground for hope than the primary one.

In like manner the operative which answers to this speculative part, starting from the ordinary incidents of nature, extends its operation to things immediately adjoining, or at least not far removed. But as for any profound and radical operations on nature, they depend entirely on the primary axioms. And in those things too where man has no means of operating, but only of knowing, as in the heavenly bodies (for these he cannot operate upon or change or transform), the investigation of the fact itself or truth of the thing, no less than the knowledge of the causes and consents, must come from those primary and catholic axioms concerning simple natures ; such as the nature of spontaneous rotation, of attraction or magnetism, and of many others which are of a more general form than the heavenly bodies themselves. For let no one hope to decide the question whether it is the earth or heaven that really revolves in the diurnal motion, until he has first comprehended the nature of spontaneous rotation.

VI.

But this Latent Process, of which I speak, is quite another thing than men, pre-occupied as their minds now are, will easily conceive. For what I understand by it is not certain measures or signs or successive steps of process in bodies which can be seen ; but a process perfectly continuous, which for the most part escapes the sense.

For instance ; in all generation and transformation of bodies, we must inquire what is lost and escapes ; what remains, what is added ; what is expanded, what contracted ; what is united, what separated ; what is continued, what cut off ; what propels, what hinders ; what predominates, what yields ; and a variety of other particulars.

Again, not only in the generation or transformation of bodies are these points to be ascertained, but also in all other alterations and motions it should in like manner be inquired what goes before, what comes after ; what is quicker, what more tardy ; what produces, what governs motion ; and like points ; all which nevertheless in the present state of the sciences (the texture of which is as rude as possible and good for nothing) are unknown and unhandled. For seeing that every natural action depends on things infinitely small, or at least too small to strike the sense, no one can hope to govern or change nature until he has duly comprehended and observed them.

VII.

In like manner the investigation and discovery of the *latent configuration* in bodies is a new thing, no less than the discovery of the Latent Process and of the Form [6]. For as yet we are but lingering in the outer courts of nature, nor

[6] The distinction between the Latent Process and Latent Schematism in the absolute way in which it is here stated, involves an assumption which the progress of science will

are we preparing ourselves a way into her inner chambers. Yet no one can endow a given body with a new nature, or successfully and aptly transmute it into a new body, unless he has attained a competent knowledge of the body so to be altered or transformed. Otherwise he will run into methods which, if not useless, are at any rate difficult and perverse and unsuitable to the nature of the body on which he is operating. It is clear therefore that to this also a way must be opened and laid out.

And it is true that upon the anatomy of organized bodies (as of man and animals) some pains have been well bestowed and with good effect ; and a subtle thing it seems to be, and a good scrutiny of nature. Yet this kind of anatomy is subject to sight and sense, and has place only in organized bodies. And besides it is a thing obvious and easy, when compared with the true anatomy of the Latent Configuration in bodies which are thought to be of uniform structure ; especially in things that have a specific character [7] and their parts, as iron, stone ; and again in parts of uniform structure in plants and animals, as the root the leaf, the flower, flesh, blood, and bones. But even in this kind, human industry has not been altogether wanting ; for this is the very thing aimed at in the separation of bodies of uniform structure by means of distillations and other modes of analysis ; that the complex structure of the compound may be made apparent by bringing together its several homogeneous parts. And this is of use too, and conduces to the object we are seeking ; although too often fallacious in its results, because many natures which are in fact newly brought out and superinduced by fire and heat and other modes of solution, are taken to be the effect of separation merely, and to have subsisted in the compound before. And after all, this is but a small part of the work of discovering the true Configuration in the compound body ; which Configuration is a thing far more subtle and exact, and such as the operation of fire rather confounds than brings out and makes distinct.

Therefore a separation and solution of bodies must be effected, not by fire indeed, but by reasoning and true induction, with experiments to aid ; and by a comparison with other bodies, and a reduction to simple natures and their Forms, which meet and mix in the compound. In a word we must pass from Vulcan to Minerva, if we intend to bring to light the true textures and configurations of bodies ; on which all the occult and, as they are called, specific properties and virtues in things depend ; and from which too the rule of every powerful alteration and transformation is derived.

For example, we must inquire what amount of spirit there is in every body, what of tangible essence ; and of the spirit, whether it be copious and turgid, or meagre and scarce ; whether it be fine or coarse, akin to air or to fire, brisk or sluggish, weak or strong, progressive or retrograde, interrupted or continuous, agreeing with external and surrounding objects or disagreeing, etc. In like manner we must inquire into the tangible essence (which admits of no fewer differences than the spirit), into its coats, its fibres, its kinds of texture. Moreover the disposition of the spirit throughout the corporeal frame, with its pores, passages,

probably show to be unfounded; namely, that bodies apparently at rest are so molecularly. Whereas all analogy and the fact that they act on the senses by acting mechanically on certain deferent media combine to show that we ought to consider bodies even at rest as dynamical and not as statical entities. On this view there is no difficulty in understanding the nature of what appear to be spontaneous changes, because every dynamical system carries within itself the seeds of its own decay, except in particular cases; that is, the type of motion so alters, with greater or less rapidity, that the sensible qualities associated with it pass away. The introduction of the idea of unstable equilibrium in connexion with organic chemistry, was a step in the direction which molecular Physics will probably soon take.

[7] In Bacon's time only certain things were supposed to belong to natural *species*, all others being merely *elementary*. A ruby has a specific character, is *specificatum ;* common stone or rock *non ita ;*—they are mere modifications of the element earth, etc. A "specific virtue" is a virtue given by a thing's specific character, transcending the qualities of the elements it consists of. [See note on *De Augm.* ii. 3.]

veins and cells, and the rudiments or first essays of the organized body, fall under the same investigation. But on these inquiries also, and I may say on all the discovery of the Latent Configuration, a true and clear light is shed by the primary axioms, which entirely dispels all darkness and subtlety.

VIII.

Nor shall we thus be led to the doctrine of atoms, which implies the hypothesis of a vacuum and that of the unchangeableness of matter (both false assumptions); we shall be led only to real particles, such as really exist. Nor again is there any reason to be alarmed at the subtlety of the investigation, as if it could not be disentangled; on the contrary, the nearer it approaches to simple natures, the easier and plainer will everything become; the business being transferred from the complicated to the simple; from the incommensurable to the commensurable; from surds to rational quantities; from the infinite and vague to the finite and certain; as in the case of the letters of the alphabet and the notes of music. And inquiries into nature have the best result, when they begin with physics and end in mathematics. Again, let no one be afraid of high numbers or minute fractions. For in dealing with numbers it is as easy to set down or conceive a thousand as one, or the thousandth part of an integer as an integer itself.

IX.

From the two kinds of axioms which have been spoken of, arises a just division of philosophy and the sciences; taking the received terms (which come nearest to express the thing) in a sense agreeable to my own views. Thus, let the investigation of Forms, which are (in the eye of reason at least, and in their essential law) eternal and immutable, constitute *Metaphysics;* and let the investigation of the Efficient Cause, and of Matter, and of the Latent Process, and the Latent Configuration (all of which have reference to the common and ordinary course of nature, not to her eternal and fundamental laws) constitute *Physics.* And to these let there be subordinate two practical divisions: to Physics, *Mechanics;* to Metaphysics, what (in a purer sense of the word) I call *Magic,* on account of the broadness of the ways it moves in, and its greater command over nature.

X.

Having thus set up the mark of knowledge, we must go on to precepts, and that in the most direct and obvious order. 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.

XI.

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.
10. Hot vapours and fumes, and the air itself, which conceives the most powerful and glowing heat, if confined ; as in reverberatory furnaces.
11. Certain seasons that are fine and cloudless by the constitution of the air itself, without regard to the time of year.
12. Air confined and underground in some caverns, especially in winter.
13. All villous substances, as wool, skins of animals, and down of birds, have heat.
14. All bodies, whether solid or liquid, whether dense or rare (as the air itself is), held for a time near the fire.
15. Sparks struck from flint and steel by strong percussion.
16. All bodies rubbed violently, as stone, wood, cloth, etc., insomuch that poles and axles of wheels sometimes catch fire ; and the way they kindled fire in the West Indies was by attrition.
17. Green and moist vegetables confined and bruised together, as roses packed in baskets ; insomuch that hay, if damp when stacked, often catches fire [8].
18. Quick lime sprinkled with water.
19. Iron, when first dissolved by strong waters in glass, and that without being put near the fire. And in like manner tin, etc., but not with equal intensity.
20. Animals, especially and at all times internally ; though in insects the heat is not perceptible to the touch by reason of the smallness of their size.
21. Horse-dung and like excrements of animals when fresh.
22. Strong oil of sulphur and of vitriol has the effect of heat in burning linen.

[8] "That seeds when germinating, as they lie heaped in large masses, evolve a considerable degree of heat, is a fact long known from the malting of grain ; but the cause of it was incorrectly sought for in a process of fermentation. To Göppert (*Ueber Wärmeentwickelung in der lebenden Pflanze*) is due the merit of having demonstrated that such is not the case, but that the evolution of heat is connected with the process of germination. Seeds of very different chemical composition (of different grains, of Hemp, Clover, *Spergula*, *Brassica*, etc.), made to germinate in quantities of about a pound, became heated, at a temperature of the air of 48°—66°, to 59°—120° Fahr.

"It was likewise shown by Göppert that full-grown plants also, such as Oats, Maize, *Cyperus esculentus*, *Hyoscyamus*, *Sedum acre*, etc., laid together in heaps and covered with bad conductors of heat, cause a thermometer placed among them to rise about 2°—7° (*Spergula* as much as 22°) above the temperature of the air . . .

"A very great evolution of heat occurs in the blossom of the *Aroideæ*. This is considerable even in our *Arum maculatum*, and according to Dutrochet's researches (*Comptes Rendus*, 1839, 695.) rises to 25°—27° above the temperature of the air. But this phenomenon is seen in a far higher degree in *Colocasia odora*, in which plant it has been investigated by Brougniart (*Nouv. Ann. d. Muséum*, iii.). Vrolik and Vriese (*Ann. des Sc. Nat.*, sec. ser. v. 134.) and Van Beek and Bersgma (*Obs. thermo-élect. s. l'élév. de température. des Fleurs d. Colocas. odor.* 1838). These last observers found the maximum of heat 129°, when the temperature of the air was 79°."—Mohl *On the Vegetable Cell*, translated by Arthur Henfrey, Lond. 1852, pp. 101 and 102.

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

24. Strong and well rectified spirit of wine has the effect of heat ; insomuch that the white of an egg being put into it hardens and whitens almost as if it were boiled ; and bread thrown in becomes dry and crusted like toast [9].

25. Aromatic and hot herbs, as *dracunculus*, *nasturtium vetus*, etc., although not warm to the hand (either whole or in powder), yet to the tongue and palate, being a little masticated, they feel hot and burning.

26. Strong vinegar, and all acids, on all parts of the body where there is no epidermis, as the eye, tongue ; or on any part when wounded and laid bare of the skin ; produce a pain but little differing from that which is created by heat.

27. Even keen and intense cold produces a kind of sensation of burning. Nec Boreæ penetrabile frigus adurit [10].

28. Other instances.

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

XII.

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.

Answering to the first affirmative instance. 1. The rays of the moon and of stars and comets are not found to be hot to the touch [11] ; 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.

To the 2nd. 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 Teneriffe, and among the Andes of Peru, the very tops of

[9] The analogy which Bacon here remarks, arises probably, in the second instance from the desiccative power due to the strong affinity of alcohol for water. The French chemist Lassaigne found, I believe, that alcohol extracted a red colouring matter from unboiled lobster shells ; but I am not aware that the modus operandi has in this case been explained. But by far the most remarkable case of what may be called simulated heat, is furnished by the action of carbonic acid gas on the skin. Of late years baths of this gas have been used medicinally ; but M. Boussingault long since remarked the sensation of heat which it produces. He states that at Quindiu in New Granada there are sulphur works, and that at various points nearly pure carbonic gas escapes from shallow excavations in the surface, containing, however, a trace of hydro-sulphuric acid ; that the temperature of this issuing stream of gas is lower than the external air, but that the sensation is the same as that produced by a hot-air bath of perhaps from 40° to 45° or 48° Centigrade (104° to 118° Fahr.). As this effect has not been noticed in carbonic acid gas prepared artificially, it is probable that it requires for its production the gas to be in motion ; so that the necessary conditions are not present when the hand is inserted into a jar of the gas.

[10] Nor burns the sharp cold of the northern blast. Virgil, *Georg.* i. 93.

[11] M. Melloni has recently succeeded in making sensible the moon's calorific rays.

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 their mouth and nose, the air being from its rarity not sufficient to support respiration [12] ; 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 until the next year without being at all disturbed. And at this day travellers ascending to the top of the Peak of Teneriffe 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.

To the 2nd. 3. The reflexion 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 [13], 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 of 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

[12] Aristotle seems to be the first person who mentions this notion. See the *Problems*, xxvi. 36 ; where, however, he speaks of Athos and οἱ τοιοῦτοι, and not of Olympus. The passages on the subject are to be found in Ideler's *Meteorologia veterum Græcorum et Romanorum* (Berlin, 1832), at p. 81. Compare his edition of the *Meteorologies* of Aristotle, where he has given *in extenso* the passage in which Geminus speaks in the same manner of Mount Cyllene in Arcadia, and also a similar statement made by Philoponus with respect to Olympus. The whole class of stories seem (as Ideler following Lobeck remarks) to have somewhat of a mythical character. G. Bruno apparently confounded Philoponus with Alexander Aphrodisiensis, when in the *Cena di Cenere* he asserted that the latter mentions the sacrifices on the top of Olympus. In the passage on the subject in which we might expect to find him doing so, namely in his Commentary on the *Meteorologies*, i. c. 3, he does not specify any particular mountain.

That there is no wind nor rain on Olympus is mentioned as a common opinion by St. Augustine, *De Civ. Dei*, xvi. 27. Compare Dante, *Purg.* xxviii. 112.

[13] This of course refers to Barentz's expedition in search of a North-East passage. He passed the winter 1596–7 at Nova Zembla. [In Barentz's first voyage, 1594, he was stopped by the ice on the 13th of July, and obliged to return. In his third voyage, 1596, his first considerable check was on the 19th of July ; after which he only succeeded in coasting round the northern point of Nova Zembla till the 26th of August, where the ship stuck fast and they were forced to leave her and winter on the island, and return in their boats in the beginning of June, 1597. See the letter signed by the company : "Three Voyages by the North East," etc., Hakluyt Society, 1853, p. 191. This letter was begun on the 1st of June : "Having till this day stayed for the time and opportunity in hope to get our ship loose, and now are clean out of hope thereof, for that it lieth shut up and enclosed in the ice," etc. : and ended on the 13th, "notwithstanding that while we were making ready to be gone, we had great wind out of the west and north-west, and yet find no alteration nor bettering in the weather, and therefore in the last extremity we left it". This narrative, written by Gerrit de Veer, one of the party, was first published in Dutch in 1598 ; translated into Latin and French the same year ; into Italian in 1599 ; into English in 1609. See Introduction, p. cxviii. "Per initia mensis *Junii*" would have been more accurate.—*J. S.*]

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

To the 2nd. 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.

To the 2nd. 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 least 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 of 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.

To the 2nd. 6. Let a burning-glass also be tried with a heat that does not emit rays or light [14], 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.

To the 2nd. 7. Let a burning-glass also be tried with common flame.

To the 3rd. 8. Comets (if we are to reckon these too among meteors) [15] 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 summer time, 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.

To the 4th. 9. There are certain coruscations which give light but do not burn. And these always come without thunder.

To the 5th. 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.

To the 6th. 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

[14] Mersenne says the greater number of the experiments mentioned in the second book of the *Novum Organum* had already been made, and mentions particularly, as if he had himself tried it, the reflexion of all kinds of heat by a burning mirror. He also asserts that light is always accompanied by heat. *De la Vérité des Sciences* (1625), p. 210.

[15] That there was no reason for supposing comets to be more than merely meteoric exhalations is the thesis maintained, and doubtless with great ability, by Galileo in his *Saggiatore*,—the true view, or at least a nearer approach to it, having been propounded by the Jesuit Grassi. Bacon perhaps alludes to this controversy.

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 [16]. And in storms too at night time, the foam of the sea when violently agitated emits sparks, and this sparkling the Spaniards call *Sea Lung* [17]. 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.

To the 7th. 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 glow-worm, or of the fly called *Luciola*, found to be warm to the touch.

To the 8th. 13. In what situation and kind of soil warm baths usually spring has not been sufficiently examined ; and therefore no Negative is subjoined.

To the 9th. 14. To warm liquids I subjoin the Negative Instance of liquid itself in its natural state. For we find no tangible liquid which is warm in its own nature and remains so constantly ; but the warmth is an adventitious nature, superinduced only for the time being ; so that the liquids which in power and operation are hottest, as spirit of wine, chemical oil of spices, oil of vitriol and sulphur, and the like, which burn after a while, are at first cold to the touch. The water of natural warm baths on the other hand, if received into a vessel and separated from its springs, cools just like water that has been heated on a fire. But it is true that oily substances are less cold to the touch than watery, oil being less cold than water, and silk than linen. But this belongs to the Table of Degrees of Cold.

To the 10th. 15. In like manner to hot vapour I subjoin as a Negative the nature of vapour itself, such as we find it with us. For exhalations from oily substances, though easily inflammable, are yet not found to be warm, unless newly exhaled from the warm body.

To the 10th. 16. In like manner I subjoin as a Negative to hot air the nature of air itself. For we do not find here any air that is warm, unless it has either been confined, or compressed, or manifestly warmed by the sun, fire, or some other warm substance.

To the 11th. 17. I here subjoin the Negative of colder weather than is suitable to the season of the year, which we find occurs during east and north winds ; just as we have weather of the opposite kind with the south and west winds. So a tendency to rain, especially in winter time, accompanies warm weather ; while frost accompanies cold.

To the 12th. 18. Here I subjoin the Negative of air confined in caverns during the summer. But the subject of air in confinement should by all

[16] [This false explanation is one of Bacon's most gratuitous miscarriages. As the phenomenon admittedly does not always result on concussion, the inference breaks down. —Ed.]

[17] The phrase " pulmo marino " is as much Italian as Spanish,—except of course, that in Italian " pulmo " is replaced by " polmo,"—and is merely a translation of πνεύμων θαλάσσιος, which is used by Dioscorides, *De Materiâ Medicâ*, ii. 39. The luminous appearance arises apparently from serpent medusæ, which in texture are like the substance of the lungs, from which circumstance they derive the name which Dioscorides gives them. Cf. *De Aug.* iv. 3.

means be more diligently examined. For in the first place it may well be matter of doubt what is the nature of air in itself with regard to heat and cold. For air manifestly receives warmth from the influence of the heavenly bodies, and cold perhaps from the exhalations of the earth ; and again in the middle region of air, as it is called, from cold vapours and snow ; so that no opinion can be formed as to the nature of air from the examination of air that is at large and exposed ; but a truer judgment might be made by examining it when confined. It is however necessary for the air to be confined in a vessel of such material as will not itself communicate warmth or cold to the air by its own nature, nor readily admit the influence of the outer atmosphere. Let the experiment therefore be made in an earthen jar wrapped round with many folds of leather to protect it from the outward air, and let the vessel remain tightly closed for three or four days ; then open the vessel and test the degree of heat or cold by applying either the hand or a graduated glass.

To the 13th. 19. In like manner a doubt suggests itself, whether the warmth in wool, skins, feathers, and the like, proceeds from a faint degree of heat inherent in them, as being excretions from animals ; or from a certain fat and oiliness, which is of a nature akin to warmth ; or simply, as surmised in the preceding article, from the confinement and separation of the air. For all air that is cut off from connexion with the outer air seems to have some warmth. Try the experiment therefore with fibrous substances made of linen ; not of wool, feathers, or silk, which are excretions from animals. It should also be observed that all powders (in which there is manifestly air enclosed) are less cold than the whole substances they are made from ; as likewise I suppose that all froth (as that which contains air) is less cold than the liquor it comes from.

To the 14th. 20. To this no Negative is subjoined. For there is nothing found among us either tangible or spirituous which does not contract warmth when put near fire. There is this difference however, that some substances contract warmth more quickly, as air, oil, and water ; others more slowly, as stone and metal [18]. But this belongs to the Table of Degrees.

To the 15th. 21. To this Instance I subjoin no Negative, except that I would have it well observed that sparks are produced from flint and steel, or any other hard substance, only when certain minute particles are struck off from the substance of the stone or metal ; and that the attrition of the air does not of itself ever produce sparks, as is commonly supposed. And the sparks themselves too, owing to the weight of the ignited body, tend rather downwards than upwards ; and on going out become a tangible sooty substance.

To the 16th. 22. There is no Negative, I think, to be subjoined to this Instance. For we find among us no tangible body which does not manifestly gain warmth by attrition ; insomuch that the ancients fancied that the heavenly bodies had no other means or power of producing warmth than by the attrition of the air in their rapid and hurried revolution. But on this subject we must further inquire whether bodies discharged from engines, as balls from cannon, do not acquire some degree of heat from the very percussion, so as to be found somewhat warm when they fall. Air in motion, however, rather chills than warms, as appears from wind, bellows, and blowing with the mouth contracted. But motion of this kind is not so rapid as to excite heat, and is the motion of a mass, and not of particles ; so that it is no wonder if it does not generate heat.

To the 17th. 23. On this Instance should be made more diligent inquiry. For herbs and vegetables when green and moist seem to contain some latent heat, though so slight that it is not perceptible to the touch when they are single ; but only when they are collected and shut up together, so that their spirits may not breathe out into the air, but may mutually cherish each other ; whereupon there arises a palpable heat, and sometimes flame in suitable matter.

To the 18th. 24. On this Instance too should be made more diligent inquiry. For quick lime sprinkled with water seems to contract heat, either by the concentration of heat before dispersed, as in the above-mentioned case

[18] [This is of course an error.—ED.]

of confined herbs, or because the igneous spirit is irritated and exasperated by the water, so as to cause a conflict and reaction. Which of these two is the real cause will more readily appear if oil be poured on instead of water ; for oil will serve equally well with water to concentrate the enclosed spirit, but not to irritate it. We should also extend the experiment both by employing the ashes and rusts of different bodies, and by pouring in different liquids.

To the 19th. 25. To this Instance is subjoined the Negative of other metals which are softer and more fusible. For gold-leaf dissolved by *aqua regia* gives no heat to the touch ; no more does lead dissolved in *aqua fortis ;* neither again does quicksilver (as I remember) ; but silver itself does, and copper too (as I remember) ; tin still more manifestly ; and most of all iron and steel, which not only excite a strong heat in dissolution, but also a violent ebullition[19]. It appears therefore that the heat is produced by conflict ; the strong waters penetrating, digging into, and tearing asunder the parts of the substance, while the substance itself resists. But where the substances yield more easily, there is hardly any heat excited.

To the 20th. 26. To the heat of animals no Negative is subjoined, except that of insects (as above-mentioned), on account of their small size. For in fishes, as compared with land animals, it is rather a low degree than an absence of heat that is noted. But in vegetables and plants there is no degree of heat perceptible to the touch, either in their exudations or in their pith when freshly exposed. In animals however is found a great diversity of heat, both in their parts (there being different degrees of heat about the heart, in the brain, and on the skin) and in their accidents, as violent exercise and fevers.

To the 22nd 27. To this Instance it is hard to subjoin a Negative. Indeed the excrements of animals when no longer fresh have manifestly a potential heat, as is seen in the enriching of soil.

To the 22nd and 23rd. 28. Liquids, whether waters or oils, which possess a great and intense acridity, act like heat in tearing asunder bodies, and burning them after some time ; yet to the touch they are not hot at first. But their operation is relative and according to the porosity of the body to which they are applied. For *aqua regia* dissolves gold but not silver [20]; *aqua fortis*, on the contrary, dissolves silver, but not gold ; neither dissolves glass, and so on with others.

To the 24th. 29. Let trial be made of spirit of wine on wood ; and also on butter, wax, or pitch ; and observe whether by its heat it in any degree melts them. For the twenty-fourth instance exhibits a power in it that resembles heat in producing incrustation. In like manner therefore try its power in producing liquefaction. Let trial also be made with a graduated or calendar glass, hollow at the top ; pour into the hollow spirit of wine well rectified, cover it up that the spirit may better retain its heat, and observe whether by its heat it makes the water sink.

To the 25th. 30. Spices and acrid herbs strike hot on the palate, and much hotter on the stomach. Observe therefore on what other substances they produce the effects of heat. Sailors tell us that when large parcels and masses of spices are, after being long kept close, suddenly opened, those who first stir and take them out run the risk of fever and inflammation [21]. It can also be tried whether such spices and herbs when pounded would not dry bacon and meat hung over them, as smoke does.

[19] This ebullition is of course not the *result* of the heat, but arises from the disengagement of gas during the action of the acid on the metal.

[20] *Aqua regia* is a mixture of nitric and hydrochloric acids. Its power of dissolving gold is ascribed by Davy to the liberation of chlorine by the neutral action of the two acids. The different result in the case of silver arises from the insolubility of chloride of silver.

[21] In the *Annals of Philosophy* a case is mentioned in which the effluvia arising on the opening of a large bark store at Guayra were sufficiently powerful to cure a bad fever. [Mr. Ellis puts this note to the original without remarking that it is of contrary effect to Bacon's statement.—Ed.]

To the 26th. 31. There is an acridity or pungency both in cold things, as vinegar and oil of vitriol, and in hot, as oil of marjoram and the like. Both alike therefore cause pain in animate substances, and tear asunder and consume the parts in such as are inanimate. To this Instance again there is no Negative subjoined. Moreover we find no pain in animals, save with a certain sensation of heat.

To the 27th. 32. There are many actions common both to heat and cold, though in a very different manner. For boys find that snow after a while seems to burn their hands; and cold preserves meat from putrefaction, no less than fire; and heat contracts bodies, which cold does also. But these and similar instances may more conveniently be referred to the inquiry concerning Cold.

XIII.

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 Ætna and many other mountains, or by the conflict of bodies, as heat is caused in the dissolutions 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 [22]. 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

[22] [Another erroneous explanation. The difference is now known to be one of conductivity.—Ed.]

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 [23], though not so much as to be perceived by the touch. For not even those substances which on putrefaction turn to animalculæ, 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 odours.

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 scarce 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 [24], 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.

9. Animals increase in heat by motion and exercise, wine, feasting, venus, 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, which is their condition from the first in burning and pestilential fevers.

11. Let further inquiry be made into the different degrees of heat in different animals, as in fishes, quadrupeds, serpents, birds; and also according to their species, as in the lion, the kite, the man; for in common opinion fish are the least hot internally, and birds the hottest; especially doves, hawks, and sparrows [25].

12. Let further inquiry be made into the different degrees of heat in the different parts and limbs of the same animal. For milk, blood, seed, eggs, are found to be hot only in a moderate degree, and less hot than the outer flesh of the animal when in motion or agitated. But what the degree of heat is in the brain, stomach, heart, etc., has not yet been in like manner inquired.

13. All animals in winter and cold weather are cold externally, but internally they are thought to be even hotter.

14. The heat of the heavenly bodies, even in the hottest countries, and at the hottest times of the year and day, is never sufficiently strong to set on fire or burn the driest wood or straw, or even tinder, unless strengthened by burning-glasses or mirrors. It is however able to extract vapour from moist substances.

15. By the tradition of astronomers some stars are hotter than others. Of planets, Mars is accounted the hottest after the sun; then comes Jupiter, and then Venus [26]. Others, again, are set down as cold; the moon, for instance, and above all Saturn. Of fixed stars, Sirius is said to be the hottest, then Cor Leonis or Regulus, then Canicula, and so on.

16. The sun gives greater heat the nearer he approaches to the perpendicular or zenith; and this is probably true of the other planets also, according to the proportion of their heat. Jupiter, for instance, is hotter, probably, to us when under Cancer or Leo than under Capricorn or Aquarius.

17. We must also believe that the sun and other planets give more heat in

[23] This is true of eremacausis rather than of real putrefaction. But the distinction belongs to the recent history of chemistry.

[24] The person here referred to is Constantius II., the son of Constantine the Great. The burning heat of the fever of which he died is mentioned by Ammianus Marcellinus, l. xxi. c. 15.

[25] [Orig. *struthiones*. *Struthio* commonly means an ostrich, but Mr. Spedding surmised it to stand here for *strutheus*, the sparrow.—Ed.]

[26] By some Venus was accounted cold and moist. Vide *Margarita Phil.* p. 627. Ptolemy, however, confirms what Bacon says of her.

perigee, from their proximity to the earth, than they do in apogee. But if it happens that in some region the sun is at the same time in perigee and near the perpendicular, his heat must of necessity be greater than in a region where he is also in perigee, but shining more obliquely. And therefore the altitude of the planets in their exaltation in different regions ought to be noted, with respect to perpendicularity or obliquity.

18. The sun and other planets are supposed to give greater heat when nearer to the larger fixed stars. Thus when the sun is in Leo he is nearer Cor Leonis, Cauda Leonis, Spica Virginis, Sirius and Canicula, than when he is in Cancer, in which sign however he is nearer to the perpendicular [27]. And it must be supposed that those parts of the heavens shed the greatest heat (though it be not at all perceptible to the touch) which are the most adorned with stars, especially of a larger size.

19. Altogether, the heat of the heavenly bodies is increased in three ways; first, by perpendicularity; secondly, by proximity or perigee; thirdly, by the conjunction or combination of stars.

20. The heat of animals, and of the rays of the heavenly bodies also (as they reach us), is found to differ by a wide interval from flame, though of the mildest kind, and from all ignited bodies; and from liquids also, and air itself when highly heated by fire. For the flame of spirit of wine, though scattered and not condensed, is yet sufficient to set paper, straw, or linen on fire; which the heat of animals will never do, or of the sun without a burning-glass or mirror.

21. There are however many degrees of strength and weakness in the heat of flame and ignited bodies. But as they have never been diligently inquired into, we must pass them lightly over. It appears however that of all flame that of spirit of wine is the softest, unless perhaps *ignis fatuus* be softer, and the flames or sparklings arising from the sweat of animals. Next to this, as I suppose, comes flame from light and porous vegetable matter, as straw, reeds, and dried leaves; from which the flame from hairs or feathers does not much differ. Next perhaps comes flame from wood, especially such as contains but little rosin or pitch; with this distinction however, that the flame from small pieces of wood (such as are commonly tied up in fagots) is milder than the flame from trunks and roots of trees. And this you may try any day in furnaces for smelting iron, in which a fire made with fagots and boughs of trees is of no great use. After this I think comes flame from oil, tallow, wax, and such like fat and oily substances, which have no great acrimony. But the most violent heat is found in pitch and rosin; and yet more in sulphur, camphor, naphtha, rock-oil, and salts (after the crude matter is discharged), and in their compounds, as gunpowder, Greek fire (commonly called wild fire), and its different kinds, which have so stubborn a heat that they are not easily extinguished by water.

22. I think also that the flame which results from some imperfect metals is very strong and eager. But on these points let further inquiry be made.

23. The flame of powerful lightning seems to exceed in strength all the former; for it has even been known to melt wrought iron into drops; which those other flames cannot do.

24. In ignited bodies too there are different degrees of heat, though these again have not yet been diligently examined. The weakest heat of all, I think, is that from tinder, such as we use to kindle flame with; and in like manner that of touchwood or tow, which is used in firing cannon. After this comes ignited wood or coal, and also bricks, and the like heated to ignition. But of all ignited substances, the hottest, as I take it, are ignited metals; as iron, copper, etc. But these require further investigation.

25. Some ignited bodies are found to be much hotter than some flames. Ignited iron, for instance, is much hotter and more consuming than flame of spirit of wine.

[27] This astrological fancy was probably suggested by a wish to explain why July is hotter than June. In the division of the Zodiac into trigons each of which corresponds to one of the elements, Leo forms one of the corners of the fiery trigon; and it is moreover the sun's proper sign.

26. Of substances also which are not ignited but only heated by fire, as boiling water and air confined in furnaces, some are found to exceed in heat many flames and ignited substances.

27. Motion increases heat, as you may see in bellows, and by blowing; insomuch that the harder metals are not dissolved or melted by a dead or quiet fire, till it be made intense by blowing.

28. Let trial be made with burning-glasses, which (as I remember) act thus. If you place a burning-glass at the distance of (say) a span from a combustible body, it will not burn or consume it so easily as if it were first placed at the distance of (say) half a span, and then moved gradually and slowly to the distance of the whole span. And yet the cone and union of rays are the same; but the motion itself increases the operation of the heat [28].

29. Fires which break out during a strong wind are thought to make greater progress against than with it; because the flame recoils more violently when the wind gives way than it advances while the wind is driving it on.

30. Flame does not burst out, nor is it generated, unless some hollow space be allowed it to move and play in; except the explosive flame of gunpowder, and the like, where compression and imprisonment increase its fury.

31. An anvil grows very hot under the hammer, insomuch that if it were made of a thin plate it might, I suppose, with strong and continuous blows of the hammer, grow red like ignited iron. But let this be tried by experiment.

32. But in ignited substances which are porous, so as to give the fire room to move, if this motion be checked by strong compression, the fire is immediately extinguished. For instance, when tinder, or the burning wick of a candle or lamp, or even live charcoal or coal, is pressed down with an extinguisher, or with the foot, or any similar instrument, the operation of the fire instantly ceases.

33. Approximation to a hot body increases heat in proportion to the degree of approximation. And this is the case also with light; for the nearer an object is brought to the light, the more visible it becomes.

34. The union of different heats increases heat, unless the hot substances be mixed together. For a large fire and a small fire in the same room increase one another's heat; but warm water plunged into boiling water cools it.

35. The continued application of a hot body increases heat, because heat perpetually passing and emanating from it mingles with the previously existing heat, and so multiplies the heat. For a fire does not warm a room as well in half an hour as it does if continued through the whole hour. But this is not the case with light; for 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 may see in fires during a sharp frost. And this I think is owing not merely to the confinement and contraction of the heat, which is a kind of union, but also to irritation. Thus when air or a stick is violently compressed or bent, it recoils not merely to the point it was forced from, but beyond it on the other side. Let trial therefore be carefully made by putting a stick or some such thing into flame, and observing whether it is not burnt more quickly at the sides than in the middle of the flame.

37. There are many degrees in susceptibility of heat. And first of all it is to be observed how slight and faint a heat changes and somewhat warms even those bodies which are least of all susceptible of heat. Even the heat of the hand communicates some heat to a ball of lead or any metal, if held in it a little while. So readily and so universally is heat transmitted and excited, the body remaining to all appearance unchanged.

38. Of all substances that we are acquainted with, the one which most readily receives and loses heat is air; as is best seen in calendar glasses [air thermoscopes], which are made thus [29]. Take a glass with a hollow belly, a thin and oblong neck; turn it upside down and lower it, with the mouth downwards and

[28] The only explanation of this is, that the focal length of the lens lay between a span and half a span.

[29] I am very much inclined to think that Bacon heard of the vitrum calendare from Fludd, or à Fluctibus, as he is called in Latin, who returned from Italy in [1605], and

the belly upwards, into another glass vessel containing water ; and let the mouth of the inserted vessel touch the bottom of the receiving vessel, and its neck lean slightly against the mouth of the other, so that it can stand. And that this may be done more conveniently, apply a little wax to the mouth of the receiving glass, but not so as to seal its mouth quite up ; in order that the motion, of which we are going to speak, and which is very facile and delicate, may not be impeded by want of a supply of air.

The lowered glass, before being inserted into the other, must be heated before a fire in its upper part, that is its belly. Now when it is placed in the position I have described, the air which was dilated by the heat will, after a lapse of time sufficient to allow for the extinction of that adventitious heat, withdraw and contract itself to the same extension or dimension as that of the surrounding air at the time of the immersion of the glass ; and will draw the water upwards to a corresponding height. To the side of the glass there should be affixed a strip of paper, narrow and oblong, and marked with as many degrees as you choose. You will then see, according as the day is warm or cold, that the air contracts under the action of cold, and expands under the action of heat ; as will be seen by the water rising when the air contracts, and sinking when it dilates. But the air's sense of heat and cold is so subtle and exquisite as far to exceed the perception of the human touch, insomuch that a ray of sunshine, or the heat of the breath, much more the heat of one's hand placed on the top of the glass, will cause the water immediately to sink in a perceptible degree [30]. And yet I think that animal spirits have a sense of heat and cold more exquisite still, were it not that it is impeded and deadened by the grossness of the body.

39. Next to air, I take those bodies to be most sensitive of heat which have been recently changed and compressed by cold, as snow and ice ; for they begin to dissolve and melt with any gentle heat. Next to them, perhaps, comes quicksilver. After that follow greasy substances, as oil, butter, and the like ; then comes wood ; then water ; and lastly stones and metals, which are slow to heat, especially in the inside. These, however, when once they have acquired heat retain it very long ; in so much that an ignited brick, stone, or piece of iron, when plunged into a basin of water, will remain for a quarter of an hour, or thereabouts, so hot that you cannot touch it.

40. The less the mass of a body, the sooner is it heated by the approach of a

in whose philosophy, built upon certain abstract notions of rarefaction and condensation, perpetual reference is made to the air-thermometer, to which he gives the same name.

[30] In consequence of this description of the Vitrum Calendare, the invention of the Thermometer has been ascribed to Bacon ; but without good reason. Fludd was the first to publish an account of the Thermometer ; but Nelli says, and (admitting his authorities) truly, that Galileo's invention was anterior to any publication of Fludd's. Nelli speaks of a letter preserved in the library of his family "in copiâ", which Castelli addressed to Cesarina in 1638. Castelli says that, more than thirty-five years before, Galileo had shown him an experiment which he describes ; namely, the rise of the water into an inverted tube with a bulb at one extremity, when the open end of the tube is put into a vessel of water, and goes on, "del quale effetto il medesimo Signor Galileo si era servito per fabbricare un Istromento da esaminare i gradi del caldo e del freddo". Thus far Castelli ; but how long after the original experiment the instrument was made, does not appear from his statement. Nelli also refers to Viviani's Life of Galileo, wherein it is said that Galileo invented the Thermometer between 1593 and 1597. It has not, I think, been remarked that the rise of water under the circumstances of Galileo's original experiment had already been described in Porta's *Natural Magic ;* though, as is usually the case with Porta, one cannot be sure whether he had ever actually seen it. "Possumus etiam solo calore aquam ascendere facere. Sit dolium supra turrim, vel ligneum, vel argillaceum aut æreum, quod melius erit, et canalem habeat in medio, qui descendat inferius usque ad aquam, et in eâ submersus sit, sed adglutinatus, ne respiret. Calefiat vas superius vel sole vel igne, nam aër, qui in alvo continetur, rarefit et foras prolabitur, unde aquam in bullas tumere videbimus, mox absentiâ solis ubi vas refrigescit, aër condensatur, et quum non sufficiat inclusus aër vacuum replere, accersitur aqua et ascendit supra."—*Porta's Magic*, book xix. chap. 4.

hot body ; which shows that all heat of which we have experience is in some sort opposed to tangible matter.

41. Heat, as far as regards the sense and touch of man, is a thing various and relative ; insomuch that tepid water feels hot if the hand be cold, but cold if the hand be hot.

XIV.

How poor we are in history any one 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".

XV.

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 [31]. 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.

XVI.

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 endeavour however not to overlook any of the points which may help us towards it.

XVII.

But when I assign so prominent a part to Forms, I cannot too often warn and admonish men against applying what I say to those forms to which their thoughts and contemplations have hitherto been accustomed.

For in the first place I do not at present speak of Compound Forms, which are, as I have remarked, combinations of simple natures according to the common course of the universe ; as of the lion, eagle, rose, gold, and the like. It will be time to treat of these when we come to the Latent Processes and Latent Configurations, and the discovery of them, as they are found in what are called substances or natures concrete.

And even in the case of simple natures I would not be understood to speak of abstract forms and ideas, either not defined in matter at all, or ill defined.

[31] It was, I apprehend, the received doctrine that whatever knowledge the angelic nature is capable of it attains at once. See St. Thomas Aquinas, *Summa Theol.* Ima., q. 45, a. 2.

For when I speak of Forms, I mean nothing more than those laws and determinations of absolute actuality, which govern and constitute any simple nature, as heat, light, weight, in every kind of matter and subject that is susceptible of 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. Nor indeed do I ever allow myself to be drawn away from things themselves and the operative part. And therefore when I say (for instance) in the investigation of the form of heat, "reject rarity," or "rarity does not belong to the form of heat", it is the same as if I said, "It is possible to superinduce heat on a dense body"; or, "It is possible to take away or keep out heat from a rare body".

But if any one conceive that my Forms too are of a somewhat abstract nature, because they mix and combine things heterogeneous (for the heat of heavenly bodies and the heat of fire seem to be very heterogeneous; so do the fixed red of the rose or the like, and the apparent red in the rainbow, the opal, or the diamond; so again do the different kinds of death; death by drowning, by hanging, by stabbing, by apoplexy, by atrophy; and yet they agree severally in the nature of heat, redness, death); if any one, I say, be of this opinion, he may be assured that his mind is held in captivity by custom, by the gross appearance of things, and by men's opinions [32]. For it is most certain that these things, however heterogeneous and alien from each other, agree in the Form or Law which governs heat, redness and death; and that the power of man cannot possibly be emancipated and freed from the common course of nature, and expanded and exalted to new efficients and new modes of operation, except by the revelation and discovery of Forms of this kind. And yet, when I have spoken of this union of nature, which is the point of most importance, I shall proceed to the divisions and veins of nature, as well the ordinary as those that are more inward and exact, and speak of them in their place.

XVIII.

I must now give an example of the Exclusion or Rejection of natures which by the Tables of Presentation are found not to belong to the Form of Heat; observing in the meantime that not only each table suffices for the rejection of any nature, but even any one of the particular instances contained in any of the tables. For it is manifest from what has been said that any one contradictory instance overthrows a conjecture as to the Form. But nevertheless for clearness' sake and that the use of the tables may be more plainly shown, I sometimes double or multiply an exclusion.

An Example of Exclusion, or Rejection of Natures from the Form of Heat.

1. On account of the rays of the sun, reject the nature of the elements [33].

2. On account of common fire, and chiefly subterraneous fires (which are the most remote and most completely separate from the rays of heavenly bodies), reject the nature of heavenly bodies.

3. On account of the warmth acquired by all kinds of bodies (minerals, vegetables, skin of animals, water, oil, air, and the rest) by mere approach to a fire, or other hot body, reject the distinctive or more subtle texture of bodies.

[32] The objection here anticipated has actually been made. It has been said that we cannot be sure that any quality always proceeds from the same cause. And in truth, though the axiom "like causes produce like effects", and vice versâ, seems to be inseparable from the idea of causation, yet the force of the objection remains. For the reference of sensible qualities to outward objects involves a subjective element. The same colour, as referred to a substance as the object in which it resides, is a different thing as it is a fixed colour, or prismatic, or epipolar, etc. They agree, it may be said, in the type of undulation; but viewed as properties of bodies, or with reference to operations on them, they are distinct. And if we could go further into the mechanism of sensation, we should probably recede further both from concrete bodies and from practice.

[33] This refers to the antithesis, almost fundamental in Peripatetic physics, of the celestial and the elementary. Heat, since the sun's rays are hot, cannot depend on elemental as contradistinguished from the celestial nature.

4. On account of ignited iron and other metals, which communicate heat to other bodies and yet lose none of their weight or substance, reject the communication or admixture of the substance of another hot body.

5. On account of boiling water and air, and also on account of metals and other solids that receive heat but not to ignition or red heat, reject light or brightness.

6. On account of the rays of the moon and other heavenly bodies, with the exception of the sun, also reject light and brightness.

7. By a comparison of ignited iron and the flame of spirit of wine (of which ignited iron has more heat and less brightness, while the flame of spirit of wine has more brightness and less heat), also reject light and brightness.

8. On account of ignited gold and other metals, which are of the greatest density as a whole, reject rarity.

9. On account of air, which is found for the most part cold and yet remains rare, also reject rarity.

10. On account of ignited iron, which does not swell in bulk, but keeps within the same visible dimensions [34], reject local or expansive motion of the body as a whole.

11. On account of the dilation of air in calendar glasses and the like, wherein the air evidently moves locally and expansively and yet acquires no manifest increase of heat, also reject local or expansive motion of the body as a whole.

12. On account of the ease with which all bodies are heated, without any destruction or observable alteration, reject a destructive nature, or the violent communication of any new nature.

13. On account of the agreement and conformity of the similar effects which are wrought by heat and cold, reject motion of the body as a whole, whether expansive or contractive.

14. On account of heat being kindled by the attrition of bodies, reject a principial nature. By principial nature I mean that which exists in the nature of things positively, and not as the effect of any antecedent nature [35].

There are other natures beside these; for these tables are not perfect, but meant only for examples.

All and each of the above mentioned natures do not belong to the Form of Heat. And from all of them man is freed in his operations on Heat.

XIX.

In the process of exclusion are laid the foundations of true Induction, which however is not completed till it arrives at an Affirmative. Nor is the exclusive part itself at all complete, nor indeed can it possibly be so at first. For exclusion is evidently the rejection of simple natures; as if we do not yet possess sound and true notions of simple natures, how can the process of exclusion be made accurate? Now some of the above-mentioned notions (as that of the nature of the elements, of the nature of heavenly bodies, or rarity) are vague and ill-defined. I therefore, well knowing and nowise forgetting how great a work I am about (viz. that of rendering the human understanding a match for things and nature),

[34] [This is of course a blunder.—ED.]

[35] Bacon here anticipates not merely the essential character of the most recent theory of heat, but also the kind of evidence by which it has been established. The proof that caloric does not exist,—in other words that heat is not the manifestation of a peculiar substance diffused through nature,—rests mainly on experiments of friction.

Mr. Joule and Professor Thomson ascribe the discovery of this proof chiefly to Sir Humphrey Davy (see Beddoes's *Contributions to Physical and Medical Knowledge*, p. 14): but though Davy's experiments guard against sources of error of which Bacon takes no notice, the merit of having perceived the true significance of the production of heat by friction belongs of right to Bacon.

It is curious that in the essay in which he opposes the doctrine of caloric, Davy endeavours to introduce a new error of the same kind, and to show that light really is a natura principialis, a peculiar substance which in combination with oxygen properly so called constitutes oxygen gas, which he accordingly calls phosoxygen.

do not rest satisfied with the precepts I have laid down ; but proceed further to devise and supply more powerful aids for the use of the understanding ; which I shall now subjoin. And assuredly in the Interpretation of Nature the mind should by all means be so prepared and disposed, that while it rests and finds footing in due stages and degrees of certainty, it may remember withal (especially at the beginning) that what it has before it depends in great measure upon what remains behind.

XX.

And yet since truth will sooner come out from error than from confusion, I think it expedient that the understanding should have permission, after the three Tables of First Presentation (such as I have exhibited) have been made and weighed, to make an essay of the Interpretation of Nature in the affirmative way ; on the strength both of the instances given in the tables, and of any others it may meet with elsewhere. Which kind of essay I call the *Indulgence of the Understanding*, or the *Commencement of Interpretation*, or the *First Vintage*.

First Vintage concerning the Form of Heat.

It is to be observed that the Form of a thing is to be found (as plainly appears from what has been said) in each and all the instances in which the thing itself is to be found ; otherwise it would not be the Form. It follows therefore that there can be no contradictory instance. At the same time the Form is found much more conspicuous and evident in some instances than in others ; namely in those wherein the nature of the Form is less restrained and obstructed and kept within bounds by other natures. Instances of this kind I call Shining or Striking Instances. Let us now therefore proceed to the First Vintage concerning the Form of Heat.

From a survey of the instances, all and each, the nature of which Heat is a particular case appears to be Motion. This is displayed most conspicuously in flame, which is always in motion, and in boiling or simmering liquids, which also are in perpetual motion. It is also shown in the excitement or increase of heat caused by motion, as in bellows and blasts ; on which see Tab. 3, Inst. 29 ; and again in other kinds of motion, on which see Tab. 3, Inst. 28 and 31. Again it is shown in the extinction of fire and heat by any strong compression, which checks and stops the motion ; on which see Tab. 3, Inst. 30 and 32. It is shown also by this, that all bodies are destroyed, or at any rate notably altered by all strong and vehement fire and heat ; whence it is quite clear that heat causes a tumult and confusion and violent motion in the internal parts of a body which perceptibly tends to its dissolution.

When I say of Motion that it is as the genus of which heat is a species, I would be understood to mean, not that heat generates motion or that motion generates heat (though both are true in certain cases), but that Heat itself, its essence and quiddity, is Motion and nothing else ; limited however by the specific difference which I will presently subjoin, as soon as I have added a few cautions for the sake of avoiding ambiguity.

Sensible heat is a relative notion, and has relation to man, not to the universe ; and is correctly defined as merely the effect of heat on the animal spirits. Moreover, in itself it is variable, since the same body, according as the senses are predisposed, induces a perception of cold as well as of heat. This is clear from Inst. 41, Tab. 3.

Nor again must the communication of Heat, or its transitive nature, by means of which a body becomes hot when a hot body is applied to it, be confounded with the Form of Heat. For heat is one thing, heating another. Heat is produced by the motion of attrition without any preceding heat, an instance which excludes heating from the Form of Heat. And even when heat is produced by the approach of a hot body, this does not proceed from the Form of Heat, but depends entirely on a higher and more general nature, viz. on the nature of assimilation or self-multiplication, a subject which requires a separate inquiry.

Again, our notion of fire is popular, and of no use ; being made up of the combination in any body of heat and brightness, as in common flame and bodies heated to redness.

Having thus removed all ambiguity, I come at length to the true specific differences which limit Motion and constitute it the Form of Heat.

The first difference then is this. Heat is an expansive motion, whereby a body strives to dilate and stretch itself to a larger sphere or dimension than it had previously occupied. This difference is most observable in flame, where the smoke or thick vapour manifestly dilates and expands itself into flame.

It is shown also in all boiling liquid, which manifestly swells, rises, and bubbles ; and carries on the process of self-expansion, till it turns into a body far more extended and dilated than the liquid itself, namely, into vapour. smoke, or air.

It appears likewise in all wood and combustibles, from which there generally arises exudation and always evaporation.

It is shown also in the melting of metals, which, being of the compactest texture, do not readily swell and dilate ; but yet their spirit being dilated in itself, and thereupon conceiving an appetite for further dilation, forces and agitates the grosser parts into a liquid state. And if the heat be greatly increased it dissolves and turns much of their substance to a volatile state.

It is shown also in iron or stones, which, though not melted or dissolved. are yet softened. This is the case also with sticks, which when slightly heated in hot ashes become flexible.

But this kind of motion is best seen in air, which continuously and manifestly dilates with a slight heat, as appears in Inst. 38, Tab. 3.

It is shown also in the opposite nature of cold. For cold contracts all bodies [36] and makes them shrink ; insomuch that in intense frosts nails fall out from walls, brazen vessels crack, and heated glass on being suddenly placed in the cold cracks and breaks. In like manner air is contracted by a slight chill, as in Inst. 38, Tab. 3. But on these points I shall speak more at length in the inquiry concerning Cold.

Nor is it surprising that heat and cold should exhibit many actions in common (for which see Inst. 32, Tab. 2), when we find two of the following specific differences (of which I shall speak presently) suiting either nature ; though in this specific difference (of which I am now speaking) their actions are diametrically opposite. For heat gives an expansive and dilating, cold a contractive and condensing motion.

The second difference is a modification of the former ; namely, that heat is a motion expansive or towards the circumference, but with this condition, that the body has at the same time a motion upwards. For there is no doubt that there are many mixed motions. For instance, an arrow or dart turns as it goes forward, and goes forward as it turns. And in like manner the motion of heat is at once a motion of expansion and a motion upwards. This difference is shown by putting a pair of tongs or a poker in the fire. If you put it in perpendicularly and hold it by the top, it soon burns your hand ; if at the side or from below, not nearly so soon.

It is also observable in distillations *per descensorium* ; which men use for delicate flowers, that soon lose their scent. For human industry has discovered the plan of placing the fire not below but above, that it may burn the less. For not only flame tends upwards, but also all heat.

But let trial be made of this in the opposite nature of cold ; viz. whether cold does not contract a body downwards, as heat dilates a body upwards. Take therefore two iron rods, or two glass tubes, exactly alike ; warm them a little, and place a sponge steeped in cold water or snow at the bottom of the one, and the same at the top of the other. For I think that the extremities

[36] [This overlooks the familiar contrary case of water.—Ed.]

of the rod which has the snow at the top will cool sooner than the extremities of the other which has the snow at the bottom ; just as the opposite is the case with heat.

The third specific difference is this ; that heat is a motion of expansion not uniformly of the whole body together, but in the smaller parts of it ; and at the same time checked, repelled, and beaten back, so that the body acquires a motion alternative, perpetually quivering, striving and struggling, and irritated by repercussion, whence springs the fury of fire and heat.

This specific difference is most displayed in flame and boiling liquids, which are perpetually quivering and swelling in small portions, and again subsiding.

It is also shown in those bodies which are so compact that when heated or ignited they do not swell or expand in bulk ; as ignited iron, in which the heat is very sharp.

It is shown also in this, that a fire burns most briskly in the coldest weather.

Again, it is shown in this, that when the air is extended in a calendar glass without impediment or repulsion,—that is to say, uniformly and equably—there is no perceptible heat. Also when wind escapes from confinement, although it burst forth with the greatest violence, there is no very great heat perceptible ; because the motion is of the whole, without a motion alternating in the particles. And with a view to this, let trial be made whether flame does not burn more sharply towards the sides than in the middle of the flame.

It is also shown in this, that all burning acts on minute pores of the body burnt ; so that burning undermines, penetrates, pricks, and stings the body like the points of an infinite number of needles. It is also an effect of this, that all strong waters (if suited to the body on which they are acting) act as fire does in consequence of their corroding and pungent nature.

And this specific difference (of which I am now speaking) is common also to the nature of cold ; for in cold the contractive motion is checked by a resisting tendency to expand, just as in heat the expansive motion is checked by a resisting 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 be very different ; because we have not here on the surface of the earth anything that is intensely cold. See Inst. 27, Tab. 9.

The fourth specific difference is a modification of the last ; it is, that the preceding motion of stimulation or penetration must be somewhat rapid and not sluggish, and must proceed by particles, minute indeed, yet not the finest of all, but a degree larger.

This difference is shown by a comparison of the effects of fire with the effects of time or age. Age or time dries, consumes, undermines and reduces to ashes, no less than fire ; indeed with an action far more subtle ; but because such motion is very sluggish and acts on particles very small, the heat is not perceived.

It is also shown by comparing the dissolution of iron and gold. Gold is dissolved without any heat being excited, while the dissolution of iron is accompanied by a violent heat, though it takes place in about the same time. The reason is that in gold the separating acid enters gently and works with subtlety, and the parts of the gold yield easily ; whereas in iron the entrance is rough and with conflict, and the parts of the iron have greater obstinacy.

It is shown also to some degree in some gangrenes and mortifications, which do not excite great heat or pain on account of the subtle nature of putrefaction.

Let this then be the First Vintage or Commencement of Interpretation concerning the Form of Heat, made by way of indulgence to the understanding.

Now from this our First Vintage it follows that the Form or true definition of heat (heat, that is, in relation to the universe, not simply in relation to man)

is in few words as follows : *Heat is a motion, expansive, restrained, and acting in its strife upon the smaller particles of bodies.* But the expansion is thus modified; *while it expands all ways, it has at the same time an inclination upwards.* And the struggle in the particles is modified also ; *it is not sluggish, but hurried and with violence* [37].

[37] The Inquisition into the form of heat suggests these remarks :—

1st. A great part of it conduces in no way to the result. This may be said to be the natural consequence of the method of inquiry.

2nd. Heat (caloric) is confounded with the effects of chemical agencies, which are said "exequi opera caloris".

3rd. A greater source of confusion is the complete absence of any recognition of the principle that all bodies tend to acquire the temperature of those about them, and that the difference ad tactum which makes one body feel hotter or colder than another depends not on its being hotter or colder, but on the different degree of facility which they have in communicating their own respective temperature. In consequence of this, it had always been taught that one class of bodies were in their own nature cold, another hot, and so on. All liquids were cold. Experiments with a thermometer would have shown that they were not; but these Bacon did not try,—an instance among others how far he was from rejecting all he had been taught.

Of which remarks we may observe that, of the "Instantiæ convenientes", 13 is an instance of the third, while from 22 to the end exemplify the second ;—of the "Instantiæ in proximo", 14–19 are to be referred to the third ; from 27 to the end, to the second.

4th. Calidum and Frigidum seem to be considered distinct and not correlative qualities.

5th. The adoption of astrological fables about the hot and cold influence of the stars and planets [is to be remarked in the *Tabula Graduum*, 15 et seqq.]

Then comes the result, that the natura calidi is a motus expansivus. This is seen [in air], "Optime cernitur in aëre qui per exiguum calorem se dilatat continuo et manifesto, ut per Inst. 38 Tab. 3" : that is, by the instance of a vitrum calendare, or air-thermometer. And this is beyond question a good instance. But then in the "exemplum exclusivæ", § 11, we read "Per dilatationem aëris in vitris calendariis et similibus, qui movetur localiter et expansive manifesto, neque tamen colligit manifestum augmentum caloris, rejice etiam motum localem aut expansivum secundum totum". How is this passage to be reconciled with the preceding? For if the example of the vitrum calendare proves anything, it proves a motus expansivus secundum totum ; and if on account of our having no manifest evidence that the air waxes hot when it expands, the example does not prove this, why is it adduced? The source of this confusion I believe to be that, though Bacon saw reason to affirm expansion to be the essence of the hot, yet he was perplexed by examples of two kinds ; (*a*) bodies which do not visibly expand when they are heated, e.g. red hot iron ; (*b*) bodies which expand without becoming heated, e.g. compressed air when relieved from pressure. For the first difficulty, it might have occurred to him that the hot iron does expand, though not enough to be perceived (except by accurate measurement) to do so ; and if he had followed the indication thus given, he might have been the discoverer of a general and most important law. The difficulty which the second class of phenomena creates ought to have prevented Bacon from assigning expansion as the forma calidi,—as being that which must always make a body hot, and without which it could not become so. For it would be too liberal an interpretation to say that the expressions "motus cohibitus et refrænatus", whereby the idea of expansion is qualified, refer to a condition essential in the case of elastic fluids,—namely that the expansion in becoming heated is due to an increased elasticity, and not to any decrease of external pressure. Even had the modification required by this class of cases been introduced, there still remains that of liquids whose temperature is below that of maximum density, which is altogether intractable. Of this phenomenon, however, it would be unreasonable to expect Bacon to have known anything. But setting it aside, if it were affirmed that Bacon, after having had a glimpse of the truth suggested by some obvious phenomena, had then recourse, as he himself expresses it, to certain "differentiæ inanes" in order to save the phenomena, I think it would be hard to dispute the truth of this censure.

Nevertheless, of the matters contained in the investigation, there are several of considerable interest, though, as has been said, they are not connected with the final result.

Viewed with reference to operation it is the same thing. For the direction is this: *If in any natural body you can excite a dilating or expanding motion, and can so repress this motion and turn it back upon itself, that the dilation shall not proceed equably, but have its way in one part and be counteracted in another, you will undoubtedly generate heat;* without taking into account whether the body be elementary (as it is called) or subject to celestial influence; whether it be luminous or opaque; rare or dense; locally expanded or confined within the bounds of its first dimension; verging to dissolution or remaining in its original state; animal, vegetable, or mineral, water, oil or air, or any other substance whatever susceptible of the above-mentioned motion. Sensible heat is the same thing; only it must be considered with reference to the sense. Let us now proceed to further aids.

XXI.

The Tables of First Presentation and the Rejection or process of Exclusion being completed, and also the First Vintage being made thereupon, we are to proceed to the other helps of the understanding in the Interpretation of Nature and true and perfect Induction. In propounding which, I mean, when Tables are necessary, to proceed upon the Instances of Heat and Cold; but when a smaller number of examples will suffice, I shall proceed at large; so that the inquiry may be kept clear, and yet more room be left for the exposition of the system.

I propose to treat then in the first place of *Prerogative instances* [38]; secondly, of the *Supports of Induction;* thirdly, of the *Rectification of Induction;* fourthly, of *Varying the Investigation according to the nature of the Subject;* fifthly, of *Prerogative Natures* with respect to Investigation, or of what should be inquired first and what last; sixthly, of the *Limits of Investigation*, or a Synopsis of all Natures in the Universe; seventhly, of the *Application to Practice*, or of things in their relation to Man; eighthly, of *Preparations for Investigation;* and lastly, of the *Ascending and Descending Scale of Axioms.*

XXII.

Among Prerogative Instances I will place first *Solitary Instances.* Those are Solitary Instances which exhibit the nature under investigation in subjects which have nothing in common with other subjects except that nature; or, again, which do not exhibit the nature under investigation in subjects which resemble other subjects in every respect except in not having that nature. For it is clear that such instances make the way short, and accelerate and strengthen the process of exclusion; so that a few of them are as good as many.

For instance, if we are inquiring into the nature of Colour, prisms, crystals, which show colours not only in themselves but externally on a wall, dews, etc., are Solitary Instances. For they have nothing in common with the colours fixed in flowers, coloured stones, metals, woods, etc., except the colour. From which we easily gather that colour is nothing more than a modification of the image of light received upon the object [39], resulting in the former case from the different

The relation between heat and mechanical action has recently become the subject of some very remarkable speculations, derived from the views suggested by S. Carnot in his *Reflections sur la Puissance Motrice du Feu.* Two views have been propounded. In one (that of S. Carnot himself), mechanical action is regarded as convertible with the transference from body to body of caloric. The other rejects the notion of caloric (the substance of heat) altogether. On this view mechanical action is convertible with the generation of heat, i.e. the raising of a given quantity of a given body from one given temperature to another. Both make use of the axiom "ex nihilo nihil"; and the conclusions thus obtained, especially in the second way of considering the subject, which I cannot doubt is the true one, are most remarkable, and the more interesting because they are, so to speak, the interpretation of a maxim whose truth is admitted à priori.

[38] [As to the meaning of this term see above, p. 25-26.—Ed.]

[39] Reference is made to Telesius's system of vision. "Lux donata est facultate sese effundendi multiplicandique et aërem propriâ specie afficiendi, itaque et oculos sube-

degrees of incidence, in the latter from the various textures and configurations of the body. These instances are Solitary in respect of resemblance.

Again, in the same investigation, the distinct veins of white and black in marble, and the variegation of colour in flowers of the same species, are Solitary Instances. For the black and white streaks in marble, or the spots of pink and white in a pink [40], agree in everything almost except the colour. From which we easily gather that colour has little to do with the intrinsic nature of a body, but simply depends on the coarser and as it were mechanical arrangement of the parts. These instances are Solitary in respect of difference. Both kinds I call *Solitary Instances*, or *Ferine*,[41] to borrow a term from astronomers.

XXIII.

Among Prerogative Instances I will next place *Migratory Instances*. They are those in which the nature in question is in the process of being produced when it did not previously exist, or on the other hand of disappearing when it existed before. And therefore, in either transition, such instances are always twofold, or rather it is one instance in motion or passage, continued till it reaches the opposite state. Such instances not only accelerate and strengthen the exclusive process, but also drive the affirmative or Form itself into a narrow compass. For the Form of a thing must necessarily be something which in the course of this migration is communicated, or on the other hand which in the course of this migration is removed and destroyed. And though every exclusive promotes the affirmative, yet this is done more decidedly when it occurs in the same than in different subjects. And the betrayal of the form in a single instance leads the way (as is evident from all that has been said) to the discovery of it in all. And the simpler the Migration, the more must the instance be valued. Besides Migratory Instances are of great use with a view to operation ; because in exhibiting the form in connexion with that which causes it to be or not to be, they supply a clear direction for practice in some cases ; whence the passage is easy to the cases that lie next. There is however in these instances a danger which requires caution ; viz. lest they lead us to connect the Form too much with the efficient, and so possess the understanding, or at least touch it, with a false opinion concerning the Form, drawn from a view of the efficient. But the efficient is always understood to be merely the vehicle that carries the Form. This is a danger however easily remedied by the process of exclusion legitimately conducted.

I must now give an example of a Migratory Instance. Let the nature to be investigated be Whiteness ; an instance migrating to production or existence is glass whole and pounded. Again, simple water and water agitated into froth. For glass and water in their simple state are transparent, not white ; whereas pounded glass and water in froth are white, not transparent. We must therefore inquire what has happened to the glass or water from this Migration. For it is obvious that the Form of Whiteness is communicated and conveyed by that pounding of the glass and that agitation of the water. We find, however, that nothing has been added except the breaking up of the glass and water into small parts, and the introduction of air. But we have made no slight advance to the

undi" . . . Again, "lux quæ res quibus insunt [colores] permeat . . . ab ipsarum intingitur coloribus, et eas transvecta oculos subit."—*De Rerum Nat.* vii. 31. See also other passages of the same book. Bacon uses "imago" as equivalent to "species", the word used in the preceding quotation.

[40] [Orig. *Garophylli.*] Caryophyllea was a flower much cultivated in Holland in the sixteenth century ; see Lemmius, *De Miraculis* (1581), p. 107. (The description seems more applicable to the tulip.) The flowers meant are pinks and carnations.

[41] I believe the word which Bacon here employs is at least very much less used than another of perhaps the same origin for which he has perhaps accidentally substituted it. "Feralis," we read in the *Lexicon Mathematicum* of Vitalis (1668), which appears to give a tolerably complete vocabulary of astrological words, "apud astronomos dicitur planeta, quando fuerit in loco ubi nullam cum reliquis familiaritatem habet : quod quidem maximum est detrimentum," etc.

discovery of the Form of Whiteness when we know that two bodies, both transparent but in a greater or less degree (viz. air and water, or air and glass), do when mingled in small portions together exhibit whiteness, through the unequal refraction of the rays of light [42].

But an example must at the same time be given of the danger and caution to which I alluded. For at this point it might readily suggest itself to an understanding led astray by efficient causes of this kind, that air is always required for the Form of Whiteness, or that Whitness is generated by transparent bodies only; notions entirely false, and refuted by numerous exclusions. Whereas it will be found that (setting air and the like aside) bodies entirely even in the particles which affect vision are transparent, bodies simply uneven are white; bodies uneven and in a compound yet regular texture are all colours except black; while bodies uneven and in a compound, irregular, and confused texture are black [43]. Here then I have given an example of an Instance Migrating to production or existence in the proposed nature of Whiteness. An Instance Migrating to destruction in the same nature of Whiteness, is froth or snow in dissolution. For the water puts off Whiteness and puts on transparency, on returning to its integral state without air.

Nor must I by any means omit to mention that under Migratory Instances are to be included not only those which are passing towards production and destruction, but also those which are passing towards increase and decrease; since these also help to discover the Form, as is clear from the above definition of Form and the Table of Degrees. Thus paper, which is white when dry, but when wetted (that is, when air is excluded and water introduced) is less white and approaches nearer to the transparent, is analogous to the above given Instances.

XXIV.

Among Prerogative Instances I will put in the third place *Striking Instances*, of which I have made mention in the First Vintage concerning Heat, and which I also call *Shining Instances*, or *Instances Freed and Predominant*. They are those which exhibit the nature in question naked and standing by itself, and also in its exaltation or highest degree of power; as being disenthralled and freed from all impediments, or at any rate by virtue of its strength dominant over, suppressing and coercing them. For since every body contains in itself many forms of natures united together in a concrete state, the result is that they severally crush, depress, break, and enthrall one another, and thus the individual forms are obscured. But certain subjects are found wherein the required nature appears more in its vigour than in others, either through the absence of impediments or the predominance of its own virtue. And instances of this kind strikingly display the Form. At the same time in these instances also we must use caution, and check the hurry of the understanding. For whatever displays the Form too conspicuously, and seems to force it on the notice of the understanding, should be held suspect, and recourse be had to a rigid and careful exclusion.

To take an example; let the nature inquired into be Heat. A Striking Instance of the motion of expansion, which (as stated above) is the main element in the Form of Heat, is a calendar glass of air. For flame, though it manifestly exhibits expansion, still, as susceptible of momentary extinction, does not display the progress of expansion. Boiling water too, on account of the easy transition of water to vapour or air, does not so well exhibit the expansion of water in its own body. Again, ignited iron and like bodies are so far from displaying the progress of expansion, that in consequence of their spirit being crushed and broken by the coarse and compact particles which curb and subdue

[42] Bacon would perhaps have given as another illustration of what he has here said the beautiful whiteness of frosted silver, if he had been aware that it is in reality silver foam. It appears that when silver is in a state of fusion a very large quantity of oxygen is condensed on and within its surface, the whole of which escapes at the moment of solidification. This explanation of the appearance of granulated silver is due, I believe, to Gay Lussac.

[43] Compare *Valerius Terminus*, ch. xi.

it, the expansion itself is not at all conspicuous to the senses. But a calendar glass strikingly displays expansion in air, at once conspicuous, progressive, permanent, and without transition.

To take another example; let the nature inquired into be Weight. A Striking Instance of weight is quicksilver. For it far surpasses in weight all substances but gold, and gold itself is not much heavier [44]. But quicksilver is a better instance for indicating the Form of Weight than gold; because gold is solid and consistent, characteristics which seem related to density; whereas quicksilver is liquid and teeming with spirit, and yet is heavier by many degrees than the diamond and other bodies that are esteemed the most solid. From which it is obvious that the Form of Heaviness or Weight depends simply on quantity of matter and not on compactness of frame.

XXV.

Among Prerogative Instances I will put in the fourth place *Clandestine Instances*, which I also call *Instances of the Twilight*, and which are pretty nearly the opposites of Striking Instances. For they exhibit the nature under investigation in its lowest degree of power, and as it were in its cradle and rudiments; striving indeed and making a sort of first attempts, but buried under and subdued by a contrary nature. Such instances however are of very great service for the discovery of Forms; because as Striking Instances lead easily to specific differences, so are Clandestine Instances the best guides to *genera*, that is, to those common natures whereof the natures proposed are nothing more than particular cases.

For example, let the nature proposed be Consistency, or the nature of that which determines its own figure; opposed to which is Fluidity. Those are Clandestine Instances which exhibit some feeble and low degree of consistency in a fluid; as a bubble of water, which is a sort of consistent pellicle of determined figure, made of the body of the water. Of a similar kind are the droppings from a house, which if there be water to follow, lengthen themselves out into a very thin thread, to preserve the continuity of the water; but if there be not water enough to follow, then they fall in round drops, which is the figure that best preserves the water from a solution of continuity. But at the very moment of time when the thread of water ceases and the descent in drops begins, the water itself recoils upwards to avoid discontinuation. Again in metals, which in fusion are liquid but more tenacious, the molten drops often fly to the top and stick there. A somewhat similar instance is that of children's looking-glasses, which little boys make on rushes with spittle; where also there is seen a consistent pellicle of water. This however is much better shown in that other childish sport, when they take water, made a little more tenacious by soap, and blow it through a hollow reed, and so shape the water into a sort of castle of bubbles; which by the interposition of the air become so consistent as to admit of being thrown some distance without discontinuation [45]. But best of all is it seen in frost and snow, which assume such a consistency that they can be almost cut with a knife, although they are formed out of water, both fluids. All which facts not obscurely intimate that Consistent and Fluid are only vulgar notions, and relative to the sense; and that in fact there is inherent in all bodies a disposition to shun and escape discontinuation; but that it is faint and feeble in homogeneous bodies (as fluids), more lively and strong in bodies compounded of heterogeneous matter; the reason being that the approach of heterogeneous matter binds bodies together, while the insinuation of homogeneous matter dissolves and relaxes them.

To take another instance, let the proposed nature be the attraction or coming

[44] This mistake occurs also in the *Historia Densi et Rari*. According to Bacon, the density of mercury is to that of gold as thirty-nine is to forty, nearly; the real ratio being little more than as seven to ten. The way in which his experiments were made account for a large part of this error.

[45] Far tougher bubbles than the ordinary kind may be blown in water in which silk cocoons have been steeped. Some curious experiments on this subject are mentioned in Porter on *Silk Manufactures* (Lardner's Cyclop.).

together of bodies. In the investigation of its Form the most remarkable Striking Instance is the magnet. But there is a contrary nature to the attractive; namely, the non-attractive, which exists in a similar substance. Thus there is iron, which does not attract iron, just as lead does not attract lead, nor wood wood, nor water water. Now a Clandestine Instance is a magnet armed with iron, or rather the iron in an armed magnet. For it is a fact in nature that an armed magnet at some distance off does not attract iron more powerfully than an unarmed magnet. But if the iron be brought so near as to touch the iron in the armed magnet, then the armed magnet supports a far greater weight of iron than a simple and unarmed magnet; on account of the similarity of substance between the pieces of iron; an operation altogether clandestine and latent in the iron before the magnet was applied [46]. Hence it is manifest that the Form of Coition is something which is lively and strong in the magnet, feeble and latent in iron. Again, it has been observed that small wooden arrows without an iron point, discharged from large engines, pierce deeper into wooden materials (say the sides of ships, or the like) than the same arrows tipped with iron, an account of the similarity of substance between the two pieces of wood; although this property had previously been latent in the wood. In like manner, although air does not manifestly attract air, or water water in entire bodies, yet a bubble is more easily dissolved on the approach of another bubble then if that other bubble were away, by reason of the appetite of coition between water and water, and between air and air. Such Clandestine Instances (which, as I have said, are of the most signal use) exhibit themselves most conspicuously in small and subtle portions of bodies; the reason being that larger masses follow more general forms; as shall be shown in the proper place.

XXVI.

Among Prerogative Instances I will put in the fifth place *Constitutive Instances*, which I also call *Manipular*. They are those which constitute a single species of the proposed nature a sort of Lesser Form. For since the genuine Forms (which are always convertible with the proposed natures) lie deep and are hard to find, it is required by the circumstances of the case and the infirmity of the human understanding that particular Forms, which collect together certain groups of instances (though not all) into some common notion, be not neglected, but rather be diligently observed. For whatever unites nature, though imperfectly, paves the way to the discovery of Forms. Instances therefore which are useful in this regard are of no despicable power, but have a certain prerogative.

But great caution must here be employed, lest the human understanding, after having discovered many of those particular Forms and thereupon established partitions or divisions of the nature in question, be content to rest therein, and instead of proceeding to the legitimate discovery of the great Form, take it for granted that the nature from its very roots is manifold and divided, and so reject and put aside any further union of the nature, as a thing of superfluous subtlety and verging on mere abstraction.

For example, let the proposed nature be Memory, or that which excites and aids the memory. Constitutive Instances are, order or distribution, which clearly aids the memory; also topics or "places" in artificial memory; which may either be *places* in the proper sense of the word, as a door, angle, window, and the like; or familiar and known persons; or any other things at pleasure (provided they be placed in a certain order), as animals, vegetables; words too, letters, characters, historical persons, and the like; although some of these are more suitable and convenient than others. Such artificial places help the memory wonderfully, and exalt it far above its natural powers. Again, verse is learnt and remembered more easily than prose. From this group of three instances, viz. order, artificial places, and verse, one species of aid to the memory

[46] This explanation of the effect of arming a magnet is wholly unsatisfactory. Before the *Novum Organum* was published, Galileo had shown that the armature acts by producing a more perfect contact. See the *Dialogi dei Sistemi massimi*, Giorn. 3ª, p. 440. I quote from the new edition, Firenze, 1842.

is constituted. And this species may with propriety be called the cutting off of infinity. For when we try to recollect or call a thing to mind, if we have no prenotion or perception of what we are seeking, we seek and toil and wander here and there, as if in infinite space. Whereas if we have any sure prenotion, infinity is at once cut off, and the memory has not so far to range. Now in the three foregoing instances the prenotion is clear and certain. In the first it must be something which suits the order; in the second it must be an image which bears some relation or conformity to the places fixed; in the third, it must be words that fall into the verse; and thus infinity is cut off. Other instances, again, will give us this second species; that whatever brings the intellectual conception into contact with the sense (which is indeed the method most used in mnemonics) assists the memory. Other instances will give us this third species; that things which make their impression by way of a strong affection, as by inspiring fear, admiration, shame, delight, assist the memory. Other instances will give us this fourth species; that things which are chiefly imprinted when the mind is clear and not occupied with anything else either before or after, as what is learnt in childhood, or what we think of before going to sleep, also things that happen for the first time, dwell longest in the memory. Other instances will give us this fifth species; that a multitude of circumstances or points to take hold of aids the memory; as writing with breaks and divisions, reading or reciting aloud. Lastly other instances will give us this sixth species; that things which are waited for and raise the attention dwell longer in the memory than what flies quickly by. Thus, if you read anything over twenty times, you will not learn it by heart so easily as if you were to read it only ten, trying to repeat it between whiles, and when memory failed looking at the book. It appears then that there are six Lesser Forms of aids to the memory; viz. the cutting off of infinity; the reduction of the intellectual to the sensible; impression made on the mind in a state of strong emotion; impression made on the mind disengaged; multitude of points to take hold of; expectation beforehand.

To take another example, let the proposed nature be Taste or Tasting. The following instances are Constitutive. Persons who are by nature without the sense of smell cannot perceive or distinguish by taste food that is rancid or putrid, nor food that is seasoned with garlic, or with roses, or the like. Again, persons whose nostrils are accidentally obstructed by a catarrh cannot distinguish or perceive anything putrid or rancid or sprinkled with rosewater. Again, persons thus affected with catarrh if while they have something fetid or perfumed in their mouth or palate they blow their nose violently, immediately perceive the rancidity or the perfume. These instances then will give and constitute this species, or rather division, of taste; that the sense of taste is in part nothing else than an internal smell, passing and descending from the upper passages of the nose to the mouth and palate. On the other hand the tastes of salt, sweet, sour, acid, rough, bitter, and the like, are as perceptible to those in whom the sense of smell is wanting or stopped as to any one else; so that it is clear that the sense of taste is a sort of compound of an internal smell and a delicate power of touch; of which this is not the place to speak.

To take another example, let the proposed nature be the communication of quality without admixture of substance. The instance of light will give or constitute one species of communication; heat and the magnet another. For the communication of light is momentaneous, and ceases at once on the removal of the original light. But heat and the virtue of the magnet, after they have been transmitted to or rather excited in a body, lodge and remain there for a considerable time after the removal of the source of motion.

Very great in short is the prerogative of Constitutive Instances; for they are of much use in the forming of definitions (especially particular definitions) and in the division and partition of natures; with regard to which it was not ill said by Plato, "That he is to be held as a god who knows well how to define and to divide" [47].

[47] In the *Phaedrus*, 266 B. [Noted by Dean Kitchin in his ed. of the *Novum Organum*.]

XXVII.

Among Prerogative Instances I will put in the sixth place *Instances Conformable*, or *of Analogy*; which I also call *Parallels*, or *Physical Resemblances*. They are those which represent the resemblances and conjugations of things, not in Lesser Forms (as Constitutive Instances do) but merely in the concrete. Hence they may be called the first and lowest steps toward the union of nature. Nor do they constitute any axiom immediately from the beginning, but simply point out and mark a certain agreement in bodies. But although they are of little use for the discovery of forms, they nevertheless are very serviceable in revealing the fabric of the parts of the universe, and anatomising its members; from which they often lead us along to sublime and noble axioms, especially those which relate to the configuration of the world rather than to simple forms and natures.

For example, these following are instances of Conformity; a looking-glass and the eye; and again, the construction of the ear and places returning an echo. From which conformity, to say nothing of the mere observation of the resemblance which is in many respects useful, it is easy to gather and form this axiom, —that the organs of the senses, and bodies which produce reflexions to the senses, are of a like nature. Again, upon this hint the understanding easily rises to a higher and nobler axiom, which is this: that there is no difference between the consents or sympathies of bodies endowed with sensation and those of inanimate bodies without sensation, except that in the former an animal spirit is added to the body so disposed, but is wanting in the latter. Whence it follows that there might be as many senses in animals as there are sympathies between inanimate bodies, if there were perforations in the animate body, allowing the animal spirit to pass freely into a member rightly disposed, as into a fit organ. Again, as many as are the senses in animals, so many without doubt are the motions in an inanimate body where animal spirit is wanting; though necessarily there are many more motions in inanimate bodies than there are senses in animate, on account of the paucity of organs of sense. And of this a manifest example is exhibited in pain. For though there are many kinds and varieties of pain in animals (as the pain of burning, for one, of intense cold for another; again, of pricking, squeezing, stretching, and the like), it is yet most certain that all of them, as far as the motion is concerned, exist in inanimate substances; for example, in wood or stone, when it is burnt or frozen or pricked or cut or bent or stretched, and so on; though they do not enter the senses for want of the animal spirit.

Again, the roots and branches of plants (which may seem strange) are Conformable Instances. For all vegetable matter swells and pushes out its parts to the surface, as well upwards as downwards. Nor is there any other difference between roots and branches than that the root is buried in the ground, while the branches are exposed to the air and sun [48]. For if you take a tender and flourishing branch of a tree, and bend it down into a clod of earth, although it does not cohere with the ground itself, it presently produces not a branch but a root. And *vice versâ*, if earth be placed at the top, and so kept down with a stone or any hard substance as to check the plant and prevent it from shooting upwards, it will put forth branches into the air downwards.

Again, the gums of trees, and most rock gems, are Conformable Instances. For both of these are nothing else than exudations and filterings of juices; the former from trees, the latter from rocks: whence is produced the splendour and clearness in each; that is, by the fine and delicate filtering. Hence too it is that the hairs of animals are not generally so beautiful and of so vivid a colour as the feathers of birds; viz. because the juices do not filter so finely through skin as through quills.

Again, the scrotum in males and the matrix in females are Conformable Instances. So that the great organic difference between the sexes (in land animals

[48] In many plants part of the stem grows underground, while in others part at least of the root is above the surface. The true distinction has relation to the functions of the two organs. There is nothing in the root analogous (except under special circumstances) to buds or nodes, and consequently no true ramification.

at least) appears to be nothing more than that the one organization is external, and the other internal [49]. That is to say, the greater force of heat in the male thrusts the genitals outwards; whereas in the female the heat is too feeble to effect this, and thus they are contained within.

The fins of fish again and the feet of quadrupeds, or the feet and wings of birds, are Conformable Instances; to which Aristotle has added the four folds in the motions of serpents [50]. Whence it appears that in the structure of the universe the motions of living creatures are generally effected by a quaternion of limbs or of bendings.

Again, the teeth of land animals and the beaks of birds are Conformable Instances; from which it is manifest that in all perfect animals there is a determination of some hard substance to the mouth.

Nor is that an absurd similitude or conformity which has been remarked between man and a plant inverted. For the root of the nerves and faculties in animals is the head, while the seminal parts are the lowest,—the extremities of the legs and arms not reckoned. In a plant on the other hand, the root (which answers to the head) is regularly placed in the lowest part, and the seeds in the highest [51].

To conclude, it cannot too often be recommended and enjoined, that men's diligence in investigating and amassing natural history be henceforward entirely changed, and turned into the direction opposite to that now in use. For hitherto men have used great and indeed over-curious diligence in observing the variety of things, and explaining the exact specific differences of animals, herbs, and fossils; most of which are rather sports of nature than of any serious use towards science. Such things indeed serve to delight, and sometimes even give help in practice; but for getting insight into nature they are of little service or none. Men's labour therefore should be turned to the investigation and observation of the resemblances and analogies of things, as well in wholes as in parts. For these it is that detect the unity of nature, and lay a foundation for the constitution of sciences [52].

But here must be added a strict and earnest caution, that those only are to be taken for Conformable and Analogous Instances which indicate (as I said at the beginning) Physical Resemblances; that is, real and substantial resemblances; resemblances grounded in nature, not accidental or merely apparent; much less superstitious or curious resemblances, such as the writers on natural magic (very frivolous persons, hardly to be named in connexion with such serious matters as we are now about) are everywhere parading; similitudes and sympathies of

[49] This remark seems to have been suggested by a similar passage in Telesius, *De Rerum Naturâ*, vi. 18.:—"Masculo . . . magnus datus est calor, qui et membrum genitale foras propellat et sanguinem multum beneque omnem compactum conficiat, etc. Fœminæ autem . . . languens inditus est calor, qui neque genitale vas foras propellere nec è semine spiritum educere queat." The doctrine however of this passage was first taught by Galen, from whom Telesius derived it. See Galen, *De Usu Partium*, xiv. 6.

[50] De Anim. Incessu, i. 7.

[51] On the other hand, one is tempted to trace an analogy between the flower in plants and the skull in man and vertebrate animals in general: each occurring at the end of the axis of development, and each consisting of four segments—whorls or vertebræ. But by far the most remarkable analogy between plants and animals relates to the mode of development of their tissues, which, there is reason to believe, were all primarily formed from cells. The evidence in favour of this proposition is perhaps not yet quite complete.

It is curious that, after it had been established in the case of plants, Schleiden conceived that in this unity of original structure he had found a character peculiar to vegetable life, so that the analogy between plants and animals seemed to be impaired by the discovery.

[52] "Natura infinita est, sed qui symbola animadverterit omnia intelliget, licet non omnino," are the words of a great poet, who perhaps also is entitled to be called a great philosopher. They form the motto of one of the happiest illustrations of what Bacon meant by *instantia conformis*,—the Parthenogenesis of Professor Owen.

things that have no reality, which they describe and sometimes invent with great vanity and folly.

But to leave these ; the very configuration of the world itself in its greater parts presents Conformable Instances which are not to be neglected. Take for example Africa and the region of Peru with the continent stretching to the Straits of Magellan, in each of which tracts there are similar isthmuses and similar promontories ; which can hardly be by accident [53].

Again, there is the Old and New World ; both of which are broad and extended towards the north, narrow and pointed towards the south.

We have also most remarkable Instances of Conformity in the intense cold existing in what is called the middle region of the air and the violent fires which are often found bursting forth from beneath the ground ; which two things are *ultimities* and extremes ; that is to say, the extreme of the nature of cold towards the circumferance of the sky, of heat towards the bowels of the earth ; by *antiperistasis* or the rejection of the contrary nature.

Lastly, the Conformity of Instances in the axioms of science is deserving of notice. Thus the rhetorical trope of deceiving expectation is conformable with the musical trope of avoiding or sliding from the close or cadence : the mathematical postulate that if two things are equal to the same thing they are equal to one another, is conformable with the rule of the syllogism in logic which unites propositions agreeing in a middle term [54]. In fine, a certain sagacity in investigating and hunting out Physical Conformities and Similitudes is of very great use in very many cases.

XXVIII.

Among Prerogative Instances I will put in the seventh place *Singular Instances ;* which I also call *Irregular* or *Heteroclite ;* to borrow a term from grammarians. They are such as exhibit bodies in the concrete, which seem to be out of the course and broken off from the order of nature, and not agreeing with other bodies of the same kind. For Conformable Instances are like each other ; Singular Instances are like themselves alone. The use of Singular Instances is the same as that of Clandestine ; namely to raise and unite nature for the purpose of discovering kinds or common natures, to be afterwards limited by true specific differences. For we are not to give up the investigation, until the properties and qualities found in such things as may be taken for miracles of nature be reduced and comprehended under some Form or fixed Law ; so that all the irregularity or singularity shall be found to depend on some common Form, and the miracle shall turn out to be only in the exact specific differences, and the degree, and the rare concurrence ; not in the species itself ; whereas now the thoughts of men go no further than to pronounce such things the secrets and mighty works of nature, things as it were causeless, and exceptions to general rules.

Examples of Singular Instances are the sun and moon among stars ; the magnet among stones ; quicksilver among metals ; the elephant among quadrupeds ; the venereal sense among kinds of touch ; the scent of hounds among kinds of smell.

[53] A. von Humboldt has pointed out the conformity of the opposite shores of the Atlantic—the approximate correspondence between the projections on each side and the recesses on the other. But Bacon apparently compares not the opposite but the corresponding coasts of Africa and America. C. Concepcion would correspond to C. Negro ; but the parallelism is not very close.

[54] The importance of the parallel here suggested was never understood until the present time, because the language of mathematics and of logic has hitherto not been such as to permit the relation between them to be recognised. Mr. Boole's *Laws of Thought* contains the first development of ideas of which the germ is to be found in Bacon and Leibnitz ; to the latter of whom the fundamental principle that in logic $a^2 = a$ was known (v. Leibnitz, *Philos. Works*, by Erdmann, 1840, p. 130). It is not too much to say that Mr. Boole's treatment of the subject is worthy of these great names.

Other calculuses of inference (using the word in its widest sense), besides the mathematical and the logical, yet perhaps remain to be developed ; but this is a subject on which it is impossible here to enter.

So among grammarians the letter S is held singular, on account of its easy combination with consonants, sometimes with two, sometimes even with three; which property no other letter has. Such instances must be regarded as most valuable, because they sharpen and quicken investigation, and help to cure the understanding depraved by custom and the common course of things.

XXIX.

Among Prerogative Instances I will put in the eighth place *Deviating Instances*; that is, errors, vagaries and prodigies of nature, wherein nature deviates and turns aside from her ordinary course. Errors of nature differ from Singular Instances in this, that the latter are prodigies of species, the former of individuals. Their use is pretty nearly the same; for they correct the erroneous impressions suggested to the understanding by ordinary phenomena, and reveal Common Forms. For in these also we are not to desist from inquiry, until the cause of the deviation is discovered. This cause however does not rise properly to any Form, but simply to the latent process that leads to the Form. For he that knows the ways of nature will more easily observe her deviations; and on the other hand he that knows her deviations will more accurately describe her ways [55].

They differ in this also from Singular Instances, that they give much more help to practice and the operative part. For to produce new species would be very difficult; but to vary known species, and thereby produce many rare and unusual results is less difficult. Now it is an easy passage from miracles of nature to miracles of art. For if nature be once detected in her deviation, and the reason thereof made evident, there will be little difficulty in leading her back by art to the point whither she strayed by accident; and that not only in one case, but also in others; for errors on one side point out and open the way to errors and deflexions on all sides. Under this head there is no need of examples; they are so plentiful. For we have to make a collection or particular natural history of all prodigies and monstrous births of nature; of everything in short that is in nature new, rare, and unusual. This must be done however with the strictest scrutiny, that fidelity may be ensured. Now those things are to be chiefly suspected which depend in any way on religion; as the prodigies of Livy; and those not less which are found in writers on natural magic or alchemy, and men of that sort; who are a kind of suitors and lovers of fables. But whatever is admitted must be drawn from grave and credible history and trustworthy reports.

XXX.

Among Prerogative Instances I will put in the ninth place *Bordering Instances*; which I also call *Participles*. They are those which exhibit species of bodies that seem to be composed of two species, or to be rudiments between one species and another. These instances might with propriety be reckoned among Singular or Heteroclite Instances; for in the whole extent of nature they are of rare and extraordinary occurrence. But nevertheless for their worth's sake they should be ranked and treated separately; for they are of excellent use in indicating the composition and structure of things, and suggesting the causes of the number and quality of the ordinary species in the universe, and carrying on the understanding from that which is to that which may be.

Examples of these are: moss, which holds a place between putrescence and a plant; some comets, between stars and fiery meteors; flying fish, between birds and fish; bats, between birds and quadrupeds: also the ape, between man and beast,—

"Simia quam similis turpissima bestia nobis" [56];

likewise the biformed births of animals, mixed of different species, and the like.

XXXI.

Among Prerogative Instances I will put in the tenth place *Instances of Power*, or of the *Fasces* (to borrow a term from the badges of empire); which I also call

[55] See Owen, *On the Nature of Limbs*, p. 54.

[56] Ennius, quoted by Cicero.

Instances of the Wit, or *Hands of Man*. These are the noblest and most consummate works in each art, exhibiting the ultimate perfection of it. For since our main object is to make nature serve the business and conveniences of man, it is altogether agreeable to that object that the works which are already in man's power should (like so many provinces formerly occupied and subdued) be noted and enumerated, especially such as are the most complete and perfect ; because starting from them we shall find an easier and nearer passage to new works hitherto unattempted. For if from an attentive contemplation of these a man pushes on his work with zeal and activity, he will infallibly either advance them a little further, or turn them aside to something in their neighbourhood, or even apply and transfer them to some more noble use.

Nor is this all. But as by rare and extraordinary works of nature the understanding is excited and raised to the investigation and discovery of Forms capable of including them ; so also is this done by excellent and wonderful works of art ; and that in a much greater degree, because the method of creating and constructing such miracles of art is in most cases plain, whereas in the miracles of nature it is generally obscure. But with these also we must use the utmost caution, lest they depress the understanding and fasten it as it were to the ground.

For there is danger lest the contemplation of such works of art, which appear to be the very summits and crowning points of human industry, may so astonish and bind and bewitch the understanding with regard to them, that it shall be incapable of dealing with any other, but shall think that nothing can be done in that kind except by the same way in which these were done ; only with the use of greater diligence and more accurate preparation.

Whereas on the contrary this is certain ; that the ways and means of achieving the effects and works hitherto discovered and observed are for the most part very poor things ; and that all power of a high order depends on Forms, and is derived in order from the sources thereof ; not one of which has yet been discovered.

And therefore (as I have said elsewhere [57]) if a man had been thinking of the war engines and battering-rams of the ancients, though he had done it with all his might and spent his whole life in it, yet he would never have lighted on the discovery of cannon acting by means of gunpowder. Nor again, if he had fixed his observation and thought on the manufacture of wool and cotton, would he ever by such means have discovered the nature of the silkworm or of silk.

Hence it is that all the discoveries which can take rank among the nobler of their kind, have (if you observe) been brought to light, not by small elaborations and extensions of arts, but entirely by accident. Now there is nothing which can forestall or anticipate accident (which commonly acts only at long intervals) except the discovery of Forms.

Particular examples of such instances it is unnecessary to adduce, there is such plenty of them. For what we have to do is simply this :—to seek out and thoroughly inspect all mechanical arts, and all liberal too (as far as they deal with works), and make therefrom a collection or particular history of the great and masterly and most perfect works in every one of them, together with the mode of their production or operation.

And yet I do not tie down the diligence that should be used in such a collection to those works only which are esteemed the masterpieces and mysteries of any art, and which excite wonder. For wonder is the child of rarity ; and if a thing be rare, though in kind it be no way extraordinary, yet it is wondered at. While on the other hand things which really call for wonder on account of the difference in species which they exhibit as compared with other species, yet if we have them by us in common use, are but slightly noticed.

Now the singularities of art deserve to be noticed no less than those of nature, of which I have already spoken [58]. And as among the singularities of nature I placed the sun, the moon, the magnet, and the like,—things in fact most familiar, but in nature almost unique ; so also must we do with the singularities of art.

For example, a Singular Instance of art is paper, a thing exceedingly common. Now if you observe them with attention, you will find that artificial materials

[57] I. § 109.

[58] II. § 28.

are either woven in upright and transverse threads, as silk, woollen or linen cloth, and the like ; or cemented of concreted juices, as brick, earthenware, glass, enamel, porcelain, etc., which are bright if well united, but if not, are hard indeed but not bright. But all things that are made of concrete juices are brittle, and no way cohesive or tenacious. On the contrary paper is a tenacious substance, that may be cut or torn ; so that it imitates and almost rivals the skin or membrane of an animal, the leaf of a vegetable, and the like pieces of Nature's workmanship. For it is neither brittle like glass, nor woven as cloth ; but is in fibres, not distinct threads, just like natural materials ; so that among artificial materials you will hardly find anything similar : but it is altogether singular[59]. And certainly among things artificial those are to be preferred which either come nearest to an imitation of nature, or on the contrary overrule and turn her back.

Again, as instances of the Wit and Hand of Man, we must not altogether contemn juggling and conjuring tricks. For some of them, though in use trivial and ludicrous, yet in regard to the information they give may be of much value.

Lastly, matters of superstition and magic (in the common acceptation of the word) must not be entirely omitted. For although such things lie buried deep beneath a mass of falsehood and fable, yet they should be looked into a little ; for it may be that in some of them some natural operation lies at the bottom ; as in fascination, strengthening of the imagination, sympathy of things at a distance, transmission of impressions from spirit to spirit no less than from body to body, and the like.

XXXII.

From what has been said it is clear that the five classes of instances last mentioned (namely, Instances Conformable, Singular, Deviating, Bordering, and of Power) ought not to be reserved until some certain nature be in question (as the other instances which I have placed first, and most of those that are to follow should), but a collection of them must be begun at once, as a sort of particular history ; because they serve to digest the matters that enter the understanding, and to correct the ill complexion of the understanding itself, which cannot but be tinged and infected, and at length perverted and distorted, by daily and habitual impressions.

These instances therefore should be employed as a sort of preparative for setting right and purging the understanding. For whatever withdraws the understanding from the things to which it is accustomed, smooths and levels its surface for the reception of the dry and pure light of true ideas.

Moreover such instances pave and prepare the way for the operative part ; as will be shown in the proper place, when I come to speak of deductions leading to Practice.

XXXIII.

Among Prerogative Instances I will put in the eleventh place *Instances of Companionship and of Enmity ;* which I also call Instances of *Fixed Propositions*. They are those which exhibit a body or concrete substance, in which the nature inquired into constantly attends, as an inseparable companion ; or in which on the contrary it constantly retreats, and is excluded from companionship, as an enemy and foe. For from such instances are formed certain and universal propositions, either affirmative or negative ; in which the subject will be a body in concrete, and the predicate the nature itself that is in question. For particular propositions are in no case fixed ; I mean propositions in which the nature in question is found in any concrete body to be fleeting and moveable, that is to say accruing or acquired, or on the other hand departing or put away. Wherefore particular propositions have no prerogative above others, save only in the case of Migration, of which I have already spoken. Nevertheless even these particular propositions being prepared and collated with universal propositions are of great use, as shall be shown in the proper place. Nor even in the universal propositions do we require exact or absolute affirmation or negation. For it is

[59] It is curious that Bacon should not have remarked that all the qualities here mentioned belong to felt as well as to paper.

sufficient for the purpose in hand, even if they admit of some rare and singular exception.

The use of Instances of Companionship is to bring the Affirmative of the Form within narrow limits, For as by Migratory Instances the Affirmative of the Form is narrowed to this,—that the Form of the thing must needs be something which by the act of Migration is communicated or destroyed ; so in Instances of Companionship, the Affirmative of the Form is narrowed to this,—that the Form of the thing must needs be something which enters as an element into such a concretion of body, or contrariwise which refuses to enter ; so that he who well knows the constitution or configuration of such a body will not be far from bringing to light the Form of the nature under inquiry.

For example, let the nature in question be Heat. An Instance of Companionship is Flame. For in water, air, stone, metal, and most other substances, heat is variable, and may come and go ; but all flame is hot, so that heat is always in attendance on the concretion of flame. But no Hostile Instance of Heat is to be found here. For the senses know nothing of the bowels of the earth, and of all the bodies which we do know, there is not a single concretion that is not susceptible of heat.

But to take another instance ; let the nature in question be Consistency. A Hostile Instance is Air. For metal can be fluid and can also be consistent ; and so can glass ; water also can be consistent, when it is frozen ; but it is impossible that air should ever be consistent, or put off its fluidity.

But with regard to such Instances of Fixed Propositions I have two admonitions to give, which may help the business in hand. The first is, that if a universal affirmative or negative be wanting, that very thing be carefully noted as a thing that is not ; as we have done in the case of Heat, where a universal negative (as far as the essences that have come under our knowledge are concerned) is not to be found in the nature of things. In like manner, if the nature in question be Eternity or Incorruptibility, no universal affirmative is to be found here. For Eternity or Incorruptibility cannot be predicated of any of the bodies lying below the heavens and above the bowels of the earth. The other admonition is, that to universal propositions, affirmative or negative, concerning any concrete body, there be subjoined those concretes which seem to approach most nearly to that which is not ; as in heat, the gentlest and least burning flames ; in incorruptibility, gold, which comes nearest to it. For all such indicate the limits of nature between that which is and that which is not, and help to circumscribe Forms, and prevent them from escaping and straying beyond the conditions of matter.

XXXIV.

Among Prerogative Instances I will put in the twelfth place those *Subjunctive Instances* mentioned in the last aphorism, which I otherwise call *Instances of Ultimity or Limit*. For such instances are not only useful when subjoined to fixed propositions, but also by themselves and in their own properties. For they point out not obscurely the real divisions of nature and measures of things, and how far in any case nature may act or be acted upon, and then the passages of nature into something else. Of this kind are gold in weight ; iron in hardness ; the whale in animal bulk ; the dog in scent ; the combustion of gunpowder in rapid expansion ; and the like. Nor should extremes in the lowest degree be less noticed than extremes in the highest ; such as spirit of wine in weight [60] ; silk in softness ; the worms of the skin in animal bulk ; and the like.

XXXV.

Among Prerogative Instances I will put in the thirteenth place *Instances of Alliance or Union*. They are those which mingle and unite natures supposed to be heterogeneous, and marked and set down as such in the received divisions.

[60] Although precise directions for making ether were given by Valerius Cordus in 1544, yet it is said to have remained unnoticed until it was rediscovered in the eighteenth century. Bacon's want of acquaintance with it, implied in this and other passages, is therefore not surprising.

Instances of Alliance show that operations and effects attributed to some one heterogeneous nature as peculiar to it, may belong also to other heterogeneous natures; so that this supposed heterogeneity is proved to be not real or essential, but only a modification of a common nature. They are therefore of most excellent use in raising and elevating the understanding from specific differences to *genera*, and in dispelling phantoms and false images of things, which in concrete substances come before us in disguise. For example, let the nature in question be heat. We are told (and it seems to be a division quite received and authorized) that there are three kinds of heat; the heat of heavenly bodies, the heat of animals and the heat of fire; and that these heats (especially one of them as compared with the other two) are in their very essence and species—that is to say, in their specific nature—distinct and heterogeneous; since the heat of heavenly bodies and of animals generates and cherishes, while the heat of fire wastes and destroys. We have, therefore, an Instance of Alliance in that common case, when the branch of a vine is brought within a house where a fire is constantly kept up, and the grapes ripen on it a whole month sooner than they do out of doors; so that the ripening of fruit, even while it hangs on the tree, may be brought about by fire, though such ripening would seem to be the proper work of the sun [61]. From this beginning therefore, the understanding, rejecting the notion of essential heterogeneity, easily rises to inquire what are in reality those points of difference between the heat of the sun and of fire which cause their operations to be so dissimilar, however they may themselves partake of a common nature.

These differences will be found to be four. The first is, that the heat of the sun compared with the heat of fire is far milder and softer in degree; the second is, that in quality (at least as it reaches us through the air) it is far moister; the third (and this is the main point) is, that it is exceedingly unequal, now approaching and increased, now receding and diminished; which thing chiefly contributes to the generation of bodies. For Aristotle was right in asserting [62] that the principal cause of the generations and corruptions which are going on here on the surface of the earth is the oblique course of the sun through the zodiac; whence the heat of the sun, partly by the alternation of day and night, partly by the succession of summer and winter, becomes strangely unequal. And yet this great man must go on at once to corrupt and deprave what he has rightly discovered. For laying down the law to nature (as his way is), he very dictatorially assigns as the cause of generation the approach of the sun, and as the cause of corruption his retreat; whereas both together (the approach of the sun and his retreat), not respectively, but as it were indifferently, afford a cause both for generation and production; since inequality of heat ministers to generation and corruption, equality to conservation only. There is also a fourth specific differ-

[61] The regular use of artificial heat in greenhouses and conservatories was not known in Bacon's time. In the *Maison Champêtre*, an encyclopædia of gardening and agriculture published in 1607, nothing is said of it; nor is there anything on the subject in the writings of Porta, though in his *Nat. Mag.* he has spoken of various modes of accelerating the growth of fruits and flowers. In the *Sylva Sylvarum* (412), however, Bacon speaks of housing hot-country plants to save them, and, in the *Essay on Gardens*, of stoving myrtles. The idea of what are now called greenhouses was introduced into England from Holland about the time of the Revolution. The orangery at Heidelberg, formed, I believe, about the middle of the seventeenth century, is said to be the earliest conservatory on record.

It is related that Albertus Magnus, entertaining the emperor at Cologne during the winter, selected for the place of entertainment the garden of his monastery. Everything was covered with snow, and the guests were much inclined to be discontented; but when the feast began, the snow cleared away; the trees put forth, first leaves, then blossoms, then fruit; and the climate became that of summer. This glorious summer, which had thus abruptly succeeded to the winter of their discontent, lasted only till the conclusion of the feast, when everything resumed its former aspect. It would be a fanciful explanation, and I know not whether it has ever been suggested, to say that Albertus Magnus really entertained the emperor in a conservatory, and only led his guests through the garden. See, for the story, Grimm's *Deutsche Sagen*.

[62] *Meteorologia*, i. 14.

ence between the heat of the sun and of fire, and one of very great moment ; viz. that the sun operates by gentle action through long spaces of time, whereas the operations of fire, urged on by the impatience of man, are made to finish their work in shorter periods. But if any one were to set to work diligently to temper the heat of fire and reduce it to a milder and more moderate degree, as is easily done in many ways ; and were then to sprinkle and intermix a little moisture ; and if above all he were to imitate the heat of the sun in its inequality ; and lastly if he could submit to a slow procedure, not indeed corresponding to the operations of the sun, but yet slower than men generally adopt in working with fire ; he would speedily get rid of the notion of different kinds of heat, and would attempt to imitate, if not equal or in some cases even surpass, the works of the sun by the heat of fire. We have a similar Instance of Alliance in the revival of butterflies stupefied and half dead with cold, by slightly warming them at a fire ; so that you may easily see that fire is no more without the power of giving life to animals than of ripening vegetables. Thus also Fracastorius's celebrated invention of the heated pan with which doctors cover the heads of apoplectic patients who are given over[63], manifestly expands the animal spirits, compressed and all but extinguished by the humours and obstructions of the brain, and exciting them to motion, just as fire acts on air or water, by consequence quickens and gives them life. Eggs also are sometimes hatched by the heat of fire, which thus exactly imitates animal heat ; and there are many instances of the same kind ; so that no one can doubt that the heat of fire may in many subjects be modified so as to resemble the heat of heavenly bodies and of animals[64].

Again, let the natures in question be Motion and Rest. It appears to be a received division and drawn from the depths of philosophy, that natural bodies either move in circle, or move straight forward, or remain at rest. For there is either motion without limit, or rest at a limit, or progress towards a limit. Now that perpetual motion of rotation seems to be proper to the heavenly bodies ; station or rest seems to belong to the globe of the earth ; while other bodies (which they call heavy or light, being indeed placed out of the region to which they naturally belong) are carried towards the masses or congregations of their likes ; light bodies upwards towards the circumference of the heaven ; heavy bodies downwards towards the earth. And this is pretty talk.

But we have an Instance of Alliance in one of the lower comets, which though far below the heaven, nevertheless revolve. And Aristotle's fiction of a comet being tied to or following some particular star has long been exploded, not only because the reason for it is not probable, but because we have manifest experience of the discursive and irregular motion of comets through various parts of the sky.

Again, another Instance of Alliance on this subject is the motion of air, which within the tropics, where the circles of rotation are larger, seems itself also to revolve from east to west.

Again, another Instance would be the ebb and flow of the sea, if it be found that the waters themselves are carried in a motion of rotation (however slow and evanescent) from east to west ; though subject to the condition of being driven back twice in the day. For if things be so, it is manifest that that motion of rotation is not limited to heavenly bodies, but is shared also by air and water.

Even that property of light substances, viz. that they tend upwards, is somewhat at fault. And on this point a bubble of water may be taken as an Instance

[63] It is mentioned in the life of Fracastorius, that when dying of apoplexy, and speechless, he made signs for the application of a cucurbita (or cupping-vessel) to his head, remembering the remarkable cure which he had effected in the case of a nun at Verona. It is scarcely necessary to remark that "dry cupping," as it is called, acts simply by partially removing the pressure of the atmosphere : the heat applied to the vessel has no other effect than that of rarefying the air it contains.

[64] Bacon's rejection of the essential heterogeneity of the three species of heat is apparently taken from Telesius, *De Rerum Nat.* vi. 20. Telesius remarks, as Bacon does, that eggs may be hatched, and insects apparently dead restored to life, by means of artificial heat.

of Alliance. For if there be air under the water, it rapidly ascends to the surface, by that motion of percussion (as Democritus calls it) by which the descending water strikes and raises the air upwards ; not by any effort or struggle of the air itself. And when it is come to the surface of the water, then the air is stopped from further ascent by a slight resistance it meets with in the water, which does not immediately allow itself to be separated ; so that the desire of air to ascend must be very slight.

Again, let the nature in question be Weight. It is quite a received division, that dense and solid bodies move toward the centre of the earth, rare and light toward the circumference of the heaven, as to their proper places. Now as for this notion of places, though such things prevail in the schools, it is very silly and childish to suppose that place has any power. Therefore philosophers do but trifle when they say that if the earth were bored through, heavy bodies would stop on reaching the centre. Certainly it would be a wonderful and efficacious sort of nothing, or mathematical point, which could act on bodies, or for which bodies could have desire ; for bodies are not acted on except by bodies. But this desire of ascending and descending depends either on the configuration of the body moved or on its sympathy or consent with some other body. Now if there be found any body which, being dense and solid, does not move to the earth, there is an end of this division. But if Gilbert's opinion be received, that the earth's magnetic power of attracting heavy bodies does not extend beyond the orb of its virtue (which acts always to a certain distance and no more) [65], and if this opinion be verified by a single instance, in that we shall have got at last an Instance of Alliance on the subject of weight. But at present there does not occur any instance on this subject certain and manifest. What seems to come nearest to one is that of the waterspouts, often seen in the voyage over the Atlantic Ocean towards either of the Indies. For so great is the quantity and mass of water suddenly discharged by these waterspouts, that they seem to have been collections of water made before, and to have remained hanging in these places ; and afterwards to have been rather thrown down by some violent cause, than to have fallen by the natural motion of gravity ; so that it may be conjectured that a dense and compact mass, at a great distance from the earth would hang like the earth itself, and not fall unless thrust down. But on this point I affirm nothing certain. Meanwhile in this and many other cases it will easily be seen how poor we are in natural history, when in place of certain instances I am sometimes compelled to adduce as examples bare suppositions.

Again, let the nature in question be Discourse of Reason. The distinction between human reason and the sagacity of brutes appears to be a perfectly correct one. Yet there are certain instances of actions performed by animals, by which it seems that brutes too have some power of syllogising ; as in the old story of the crow which, in a time of great drought being half dead with thirst, saw some water in the hollow trunk of a tree ; and finding it too narrow to get in, proceeded to drop in a number of pebbles, till the water rose high enough for it to drink ; which thing afterwards passed into a proverb.

Again, let the nature in question be Visibility. It appears to be a very correct and safe division which regards light as primarily visible, and affording the power of seeing ; while colour is secondarily visible, and cannot be seen without light, so that it appears to be nothing more than an image or modification of

[65] In Gilbert's philosophy, the earth's magnetic action is not distinguished from gravity. See *De Mundo*, ii. c. 3. Again, that the magnetic action of the earth or of a magnet is confined to a definite orb appears from a variety of passages. See *De Magnete*, ii. c. 7., and the definitions prefixed to this work. Gilbert distinguished between the "orb of virtue", which includes the whole space through which any magnetic action extends, and the "orb of coition", which is "totum illud spatium per quod minimum magneticum per magnetem movetur". He asserts that the orb of the magnetic virtue extends to the moon, and ascribes the moon's inequalities to the effects it produces (*De Mundo*, ii. c. 19). In the preceding chapter he remarks, "Luna magnetice alligatur terræ, quia facies ejus semper versus terram".

light.[66] And yet there appear to be instances of alliance on either side, viz., snow in great quantities, and the flame of sulphur; in one of which there appears to be a colour primarily giving light, in the other a light verging on colour.

XXXVI.

Among Prerogative Instances I will put in the fourteenth place *Instances of the Fingerpost*[67]; borrowing the term from the fingerposts[68] which are set up where roads part, to indicate the several directions. These I also call *Decisive and Judicial*, and in some cases, *Oracular* and *Commanding Instances*. I explain them thus. When in the investigation of any nature the understanding is so balanced as to be uncertain to which of two or more natures the cause of the nature in question should be assigned, on account of the frequent and ordinary concurrence of many natures, Instances of the Fingerpost show the union of one of the natures with the nature in question to be sure and indissoluble, of the other to be varied and separable; and thus the question is decided, and the former nature is admitted as the cause, while the latter is dismissed and rejected. Such instances afford very great light, and are of high authority, the course of interpretation sometimes ending in them and being completed. Sometimes these Instances of the Fingerpost meet us accidentally among those already noticed; but for the most part they are new, and are expressly and designedly sought for and applied, and discovered only by earnest and active diligence.

For example, let the nature in question be the Ebb and Flow of the Sea; each of which is repeated twice a day, and takes six hours each time; subject to some slight difference which coincides wth the motion of the moon. The following will be a case of the parting of the roads.

This motion must necessarily be caused either by the advance and retreat of the waters; as water shaken in a basin leaves one side when it washes the other; or else by a lifting up of the waters from the bottom and falling again: as water in boiling rises and falls. The question is to which of these two causes the ebb and flow should be assigned. Now, if we take the first, it follows that when there is a flood on one side of the sea, there must be at the same time an ebb somewhere on the other. To this point therefore the inquiry is brought. Now it has been observed by Acosta and others, after careful research, that on the shores of Florida and the opposite shores of Spain and Africa the floods take place at the same times, and the ebbs take place at the same times also; and not that there is an ebb from the shores of Spain and Africa when there is a flood on the shores of Florida[69]. And yet if you look at it more closely, this does not prove the case in favour of the rising and against the progressive motion. For waters may move in progression, and yet rise upon the opposite shores of the same channel at the same time; as when they are thrust together and driven on from some other quarter. For so it is with rivers, which rise and fall on both banks at the same hours; and yet that motion is clearly one of progression; namely, of the waters entering the mouth of the rivers from the sea. It may therefore happen in a like manner that waters coming in a vast mass from the East Indian Ocean are driven together and pushed into the channel of the Atlantic, and on that account flood both sides at once. We must inquire therefore whether there be any other channel, in which the water can be retreating and ebbing at that same time; and we have the South Sea, a sea at least as wide, indeed wider and larger than the Atlantic, which is sufficient for the purpose.

At length then we have come to an Instance of the Fingerpost in this case; and it is this. If we find for certain that when there is a flood on the opposite coasts of Florida and Spain in the Atlantic, there is also a flood on the coasts of Peru

[66] The doctrine of this passage seems to be taken from Telesius, *De Rerum Naturâ*. vii. c. 31. :—"Sensus ipse primo illam [lucem] et per se visilem colores siquidem visiles at secundo a luce loco et lucis omnino opera visiles declarat."

[67] [Orig. *Instantias Crucis.*]

[68] [*I.e.* "crosses."]

[69] Compare the *De Fluxu et Refluxu Maris*. I have not been able to find this statement in Acosta, who speaks of the synchronism of the tides on the opposite sides of South America, as shown by the meeting of the tidal waves in the Straits of Magellan. (iii. 14.)

and the back of China in the South Sea, then indeed on the authority of this Decisive Instance we must reject the assertion that the ebb and flow of the sea, which is the thing inquired into, takes place by a progressive motion ; for there is no sea or place left in which the retreat or ebbing can be going on at the same time. And this may be most conveniently ascertained by asking the inhabitants of Panama and Lima (where the two Oceans, the Atlantic and Pacific, are separated by a small isthmus) whether the ebb and flow of the sea takes place on the opposite sides of the isthmus at the same time ; or contrariwise, when it is ebbing on one side it is flowing on the other. Now this decision or rejection appears to be certain, if we take it for granted that the earth is immoveable. But if the earth revolves, it is perhaps possible that in consequence of the unequal rotation (in point of speed) of the earth and waters of the sea, the waters are violently driven upwards into a heap, which is the flood, and (when they can bear no more piling) released and let down again, which is the ebb. But on this inquiry should be made separately. Still even on this hypothesis, our position remains equally fixed, that there must of necessity be an ebb of the sea going on in some parts at the same time that a flood is going on in others.

Again, let the nature in question be the latter of the two motions we have supposed ; namely, the rising and sinking motion ; if on careful examination we reject the former motion of which I spoke,—the progressive. With regard to this nature the road branches into three. For the motion by which the waters rise in the flood and sink in the ebb without any accession of other waters rolling in, must necessarily be brought about in one of these three ways. Either there is an accession of water poured out from the interior of the earth, and again retreating into it ; or there is no accession to the mass of water, but the same waters (without increase of quantity) are extended or rarefied, so as to occupy a greater space and dimension, and again contract themselves ; or there is no increase either of supply or of extension, but the same waters (the same in quantity as in density) are raised by some magnetic force attracting them from above, and by consent therewith, and then fall back again. Let us now dismiss the two former causes of motion and reduce our inquiry to the last ; that is to say, let us inquire whether any such raising by consent or magnetic force may happen. Now in the first place it is evident that the waters, as they lie in the trench or hollow of the sea, cannot all be raised at once, for want of something to take their place at the bottom ; so that even if there were in water any such desire to rise, it would be barred and checked by the cohesion of things, or (as it is commonly called) the abhorrence of a vacuum. It remains that the waters must be raised in one part, and thereby be diminished and retreat in another. Again, it will follow of necessity that the magnetic force, since it cannot act upon the whole, will act with the greatest intensity on the middle, so as to raise up the water in the middle ; upon which the rest must follow and fall away from the sides.

Thus at length we come to an Instance of the Fingerpost on this subject. For if we find that in the ebb of the sea the surface of the water is more arched and round, the waters rising in the middle of the sea and falling away from the sides, that is, the shores ; and that in the flood the same surface is more even and level, the waters returning to their former position ; then indeed on the authority of this Decisive Instance the raising by magnetic force may be admitted ; otherwise it must be utterly rejected. And this would not be difficult to ascertain by trial in straits with sounding lines [70] ; viz. whether during ebbs the sea be not higher or deeper towards the middle than during floods. It is to be observed however that, if this be the case, the waters must (contrary to the common opinion) rise in ebbs and sink in floods, so as to clothe and wash the shores.

Again, let the nature investigated be the Spontaneous Motion of Rotation ; and in particular, whether the Diurnal Motion, whereby to our eyes the sun and stars rise and set, be a real motion of rotation in the heavenly bodies, or a motion apparent in the heavenly bodies, and real in the earth. We may here take for

[70] It is scarcely necessary to remark that wherever soundings are possible, tidal phenomena are derivative, and give no direct information as to the form the ocean would assume if the hypothesis of the equilibrium theory represented the reality.

an Instance of the Fingerpost the following. If there be found in the ocean any motion from east to west, however weak and languid ; if the same motion be found a little quicker in the air, especially within the tropics, where because of the larger circles it is more perceptible ; if the same motion be found in the lower comets, but not lively and vigorous ; if the same motion be found in planets, but so distributed and graduated, that the nearer a planet is to the earth its motion is slower, the further a planet is distant from the earth its motion is quicker, and quickest of all in the starry sphere ; then indeed we should receive the diurnal motion as real in the heavens, and deny such motion to the earth ; because it will be manifest that motion from east to west is perfectly cosmical, and by consent of the universe ; being most rapid in the highest parts of the heavens, and gradually falling off, and finally stopping and becoming extinct in the immoveable,—that is, the earth [71].

Again, let the nature in question be that other Motion of Rotation so much talked of by philosophers, the Resistant and Contrary Motion to the Diurnal, viz. from west to east ; which old philosophers attribute to the planets ; also to the starry sphere ; but Copernicus and his followers to the earth as well ; and let us inquire whether any such motion be found in nature, or whether it be not rather a thing invented and supposed for the abbreviation and convenience of calculation, and for the sake of that pretty notion of explaining celestial motions by perfect circles. For this motion in the heavens is by no means proved to be true and real, either by the failing of a planet to return in its diurnal motion to the same point of the starry sphere, or by this, that the poles of the zodiac differ from the poles of the world ; to which two things we owe this idea of motion. For the first phenomenon is well accounted for by supposing that the fixed stars outrun the planets, and leave them behind ; the second, by supposing a motion in spiral lines ; so that the inequality of return and the declination to the tropics may rather be modifications of the one diurnal motion, than motions contrary or round different poles. And most certain it is, if one may but play the plain man for a moment (dismissing the fancies of astronomers and schoolmen, whose way it is to overrule the senses, often without reason, and to prefer what is obscure), that this motion does actually appear to the sense such as I have described ; for I once had a machine made with iron wires to represent it [72].

The following would be an Instance of the Fingerpost on this subject. If it be found in any history worthy of credit, that there has been any comet, whether high or low, which has not revolved in manifest agreement (however irregular) with the diurnal motion, but has revolved in the opposite direction, then certainly we may set down thus much as established, that there *may be* in nature some such motion. But if nothing of the kind can be found, it must be regarded as questionable, and recourse be had to other Instances of the Fingerpost about it.

Again, let the nature in question be Weight or Heaviness. Here the road will branch into two, thus. It must needs be that heavy and weighty bodies

[71] Nothing shows better than an instance of this kind, the impossibility of reducing philosophical reasoning to a uniform method of exclusion. How could the analogical argument in the text be stated in accordance with what Bacon seems to recognise as the only true form of induction,—that, namely, which proceeds by exclusion ? The argument depends on a wholly non-logical element, the conviction of the unity and harmony of nature.

[72] This passage does the author little credit. He does not seem to have perceived that the resolution of the apparent motion into other simpler motions was an essentially necessary step before the phenomena could be grouped together in any general law. The transition from the apparent motion to the real motions could never have been made unless the former had been resolved in the manner which Bacon here condemns. From the concluding remark no astronomer would have dissented, " talem esse motum ad sensum, qualem diximus ". About this there can be no question ; but the whole passage shows how little Bacon understood the scope and the value of the astronomy of his own time.

either tend of their own nature to the centre of the earth, by reason of their proper configuration ; or else that they are attracted by the mass and body of earth itself as by the congregation of kindred substances, and move to it by sympathy. If the latter of these be the cause, it follows that the nearer heavy bodies approach to the earth, the more rapid and violent is their motion to it ; and that the further they are from the earth, the feebler and more tardy is their motion (as is the case with magnetic attraction) ; and that this action is confined to certain limits ; so that if they were removed to such a distance from the earth that the earth's virtue could not act upon them, they would remain suspended like the earth itself, and not fall at all. With regard to this then, the following would be an Instance of the Fingerpost. Take a clock moved by leaden weights, and another moved by the compression of an iron spring ; let them be exactly adjusted, that one go not faster or slower than the other ; then place the clock moving by weights on the top of a very high steeple, keeping the other down below ; and observe carefully whether the clock on the steeple goes more slowly than it did, on account of the diminished virtue of its weights. Repeat the experiment in the bottom of a mine, sunk to a great depth below the ground ; that is, observe whether the clock so placed does not go faster than it did, on account of the increased virtue of its weights. If the virtue of the weights is found to be diminished on the steeple, and increased in the mine, we may take the attraction of the mass of the earth as the cause of weight [73].

Again, let the nature investigated be the Polarity of the Iron Needle when touched with the magnet. With regard to this nature the road will branch into two, thus. Either the touch of the magnet of itself invests the iron with polarity to the north and south ; or it simply excites and prepares the iron, while the actual motion is communicated by the presence of the earth ; as Gilbert thinks, and labours so strenuously to prove. To this point therefore tend the observations which he has collected with great sagacity and industry. One is, that an iron nail, which has lain for a long time in a direction between north and south, gathers polarity without the touch of the magnet by its long continuance in this position ; as if the earth itself, which on account of the distance acts but feebly (the surface or outer crust of the earth being destitute, as he insists, of magnetic power), were yet able by this long continuance to supply the touch of the magnet, and excite the iron, and then shape and turn it when excited. Another is, that if iron that has been heated white-hot, be while cooling laid length-wise between north and south, it also acquires polarity without the touch of the magnet ; as if the parts of the iron, set in motion by ignition, and afterwards recovering themselves, were at the very moment of cooling more susceptible and sensitive of the virtue emanating from the earth than at other times, and thus became excited by it. But these things, though well observed, do not quite prove what he asserts [74].

[73] Nothing can be more ingenious than the *instantia crucis* here proposed. A series of observations were made by Dr. Whewell and Mr. Airy to determine the effect on the time of vibration of a pendulum, produced by carrying it to the bottom of a mine ; but, probably from the effect of local attractions, the results were scarcely as satisfactory as might have been expected. In the autumn of 1854, Mr. Airy instituted similar experiments in the Harton Colliery. They appear likely to afford more satisfactory results than the older series made at Dolcoath.

Voltaire cites the passage in the text in support of his remark that "le plus grand service, peut-être, que F. Bacon ait rendu à la philosophie a été de deviner l'attraction". But in reality the notion of attraction in one form or other (e.g. the attraction of the sea by the moon) sprang up in the infancy of physical speculation ; and it cannot be affirmed that Bacon's ideas on the subject were as clear as those of his predecessor William Gilbert. (See note on *De Aug.* ii. 13) By an error similar to Voltaire's, some of Dante's commentators have claimed for him the credit of being the first to indicate the true cause of the tides. The passage on which this claim is founded is in the *Paradiso*, xvi. 82.

[74] See, for these two remarks, the twelfth chapter of the third book of Gilbert's treatise *De Magnete*. It is illustrated by a curious woodcut representing the smith forging a bar of iron, and holding it, as he does so, in the plane of the meridian.

Now with regard to this question an Instance of the Fingerpost would be the following. Take a magnetic globe [75] and mark its poles ; and set the poles of the globe towards the east and west, not towards the north and south, and let them remain so ; then place at the top an untouched iron needle, and allow it to remain in this position for six or seven days.

The needle while over the magnet (for on this point there is no dispute) will leave the poles of the earth and turn towards the poles of the magnet ; and therefore, as long as it remains thus, it points east and west. Now if it be found that the needle, on being removed from the magnet and placed on a pivot, either starts off at once to the north and south, or gradually turns in that direction, then the presence of the earth must be admitted as the cause ; but if it either points as before east and west, or loses its polarity, this cause must be regarded as questionable, and further inquiry must be made.

Again, let the nature in question be the Corporeal Substance of the Moon ; that is, let us inquire whether it be rare, consisting of flame or air, as most of the old philosophers opined ; or dense and solid, as Gilbert and many moderns, with some ancients, maintain [76]. The reasons for the latter opinion rest chiefly on this, that the moon reflects the rays of the sun ; nor does light seem to be reflected except by solid bodies. Therefore Instances of the Fingerpost on this question will (if any) be those which prove that reflexion may take place from a rare body, as flame, provided it be of sufficient denseness. Certainly one cause of twilight, among others, is the reflexion of the rays of the sun from the upper part of the air. Likewise we occasionally see rays of the sun in fine evenings reflected from the fringes of dewy clouds with a splendour not inferior to that reflected from the body of the moon, but brighter and more gorgeous [77], and yet there is no proof that these clouds have coalesced into a dense body of water. Also we observe that the dark air behind a window at night reflects the light of a candle, just as a dense body would [78]. We should also try the experiment of allowing the sun's rays to shine through a hole on some dusky blueish flame. For indeed the open rays of the sun, falling on the duller kinds of flame, appear to deaden them, so that they seem more like white smoke than flame. These are what occur to me at present as Instances of the Fingerpost, with reference to this question ; and better may perhaps be found. But it should always be observed that reflexion from flame is not to be expected, except from a flame of some depth, for otherwise it borders on transparency. This however may be set down as certain,—that light on an even body is always either received and transmitted or reflected.

Again let the nature in question be the Motion of Projectiles (darts, arrows, balls, etc.) through the air. This motion the schoolmen, as their way is, explain in a very careless manner ; thinking it enough to call it a violent motion as distinguished from what they call a natural motion ; and to account for the first percussion or impulse by the axiom that two bodies cannot occupy the same place on account of the impenetrability of matter ; and not troubling themselves at all how the motion proceeds afterwards. But with reference to this inquiry the road branches into two in this way. Either this motion is caused by the air carrying the projected body and collecting behind it, as the stream in the case of a boat, or the wind in that of straws ; or it is caused by the parts of the body itself not enduring the impression, but pushing forward in succession to relieve

[75] Orig. *Terrella*. This is a word used by Gilbert to denote a spherical magnet. One of the fundamental ideas of his philosophy was that the earth was a great magnet ; and a magnet of the same form was therefore called a "little earth," or *terrella*. See, for instance, his treatise *De Magnete*, ii. cc. 7, 8.

[76] See Gilbert's *De Mundo*, ii. c. 13 *et seqq*. [Bacon here appears to lean to the view that the moon is a vapour, see also p. 704.—Ed.]

[77] The comparison of the brightness of the moon in the daytime with that of a cloud was ingeniously applied by Bouguer to determine the ratio of the moon's light to the sun's.

[78] [It is hardly necessary to remark that it is not the air but the glass that causes the reflection.—Ed.]

themselves from it. The former of these explanations is adopted by Fracastorius and almost all who have entered into the investigation with any subtlety [79], and there is no doubt that the air *has* something to do with it : but the other motion is undoubtedly the true one, as is shown by countless experiments. Among others the following would be an Instance of the Fingerpost on this subject : that a thin iron plate or stiffish iron wire, or even a reed or pen split in half, when pressed into a curve between the finger and thumb, leaps away. For it is obvious that this motion cannot be imputed to the air gathering behind the body, because the source of motion is in the middle of the plate or reed, not in the extremities.

Again, let the nature in question be the rapid and powerful motion of the Expansion of Gunpowder into flame ; by which such vast masses are upheaved, such great weights discharged, as we see in mines and mortars. With respect to this nature the road branches into two in this way. The motion is excited either by the mere desire of the body to expand when set on fire, or partly by that and partly by the desire of the crude spirit in the body, which flies rapidly away from the fire, and bursts violently from its embrace as from a prison-house. The schoolmen and common opinion deal only with the former desire. For men fancy themselves very fine philosophers, when they assert that the flame is endowed by its elementary form with a necessity of occupying a larger space than the body had filled when in the form of powder, and that hence the motion ensues. Meanwhile they forget to notice, that although this be true on the supposition that flame is generated, it is yet possible for the generation of flame to be hindered by a mass of matter sufficient to suppress and choke it ; so that the case is not reduced to the necessity they insist on. For that expansion must necessarily take place, and that there must needs follow thereon a discharge or removal of the opposing body, if flame be generated, they rightly judge. But this necessity is altogether avoided if the solid mass suppress the flame before it be generated. And we see that flame, especially in its first generation, is soft and gentle, and requires a hollow space wherein to play and try its strength. Such violence therefore cannot be attributed to flame by itself. But the fact is, that the generation of these windy flames, or fiery winds as they may be called, arises from a conflict of two bodies of exactly opposite natures ; the one being highly inflammable, which is the nature of sulphur, the other abhorring flame, as the crude spirit in nitre ; so that there ensues a strange conflict, the sulphur kindling into flame with all its might (for the third body, the willow-charcoal, does no more than incorporate and combine the other two), while the spirit of the nitre bursts forth with all its might, and at the same time dilates itself (as air, water, and all crude bodies do when affected by heat), and by thus flying and bursting out fans meanwhile the flame of the sulphur on all sides as with hidden bellows.

On this subject we may have Instances of the Fingerpost of two kinds. The first, of those bodies which are most highly inflammable, as sulphur, camphor, naphtha and the like, with their compounds ; which catch fire more quickly and easily than gunpowder if not impeded (from which it appears that the desire of bursting into flame does not produce by itself that stupendous effect) ; the other, of those bodies which shun and abhor flame, as all salts. For we find that if salts are thrown into the fire, their aqueous spirit bursts out with a crackling noise,

[79] See Fracastorius, *De Sympathiâ et Antipathiâ*, c. 4. The notion that the air concurred in producing the continued motion of projectiles is found in the *Timæus*, p. 80. Plato has been speaking of respiration, of which his theory is, that the expiration of air through the nostrils and mouth pushes the contiguous external air from its place, which disturbs that near it, and so on until a circle is formed, whereby, by antiperistasis, air is forced in through the flesh, to fill up the cavity of the chest—a circulation of air through the body, in short. On the same principle he would have explained a variety of other phenomena—the action of cupping instruments, swallowing, the motion of projectiles, etc., etc. All these, however, after suggesting the explanation, he leaves unexplained. But Plutarch, *Quæst. Platon.* x. (p. 177. of Reiske's *Plutarch*) developes a similar explanation in each case. This explanation, however, is not Plato's but Plutarch's, though it is probably what Plato would himself have said.

before flame is caught ; which is the case also, though in a milder degree, with the stiffer kinds of leaves : the aqueous part escaping before the oily catches fire. But this is best seen in quicksilver, which is not inaptly called mineral water [80]. For quicksilver, without bursting into flame, by mere eruption and expansion almost equals the force of gunpowder,and is also said when mixed with gunpowder to increase its strength.

Again, let the nature in question be the Transitory Nature of Flame and its momentaneous extinction. For the nature of flame appears to have no fixed consistency here with us, but to be every moment generated and every moment extinguished ; for it is clear that in flames which continue and last, the continuance we see is not of the same individual flame, but is caused by a succession of new flame regularly generated ; nor does the flame remain numerically identical ; as is easily seen from this, that if the food or fuel of flame be taken away, the flame instantly goes out. With reference to this nature the roads branch into two, thus. The momentaneous nature proceeds either from a cessation of the cause which at first produced the flame, as in light, sound, and the motion called " violent " ; or from this, that the flame, though able by its own nature to remain with us, suffers violence and is destroyed by the contrary natures that surround it.

On this subject therefore we may take the following as an Instance of the Fingerpost. We see in large fires how high the flames ascend ; for the broader the base of the flame, the higher is its vertex. Thus extinction appears to commence at the sides, where the flame is compressed and troubled by the air. But the heart of the flame, which is not touched by the air but surrounded by other flame on all sides, remains numerically identical ; nor is it extinguished until gradually compressed by the surrounding air. Thus all flame is in the form of a pyramid, being broader at the base where the fuel is, but sharp at the vertex, where the air is antagonistic and fuel is wanting. But smoke is narrow at the base and grows broader as it ascends, like an inverted pyramid ; the reason being that the air admits smoke and compresses flame. For let no one dream that lighted flame is air, when in fact they are substances quite heterogeneous.

But we may have an Instance of the Fingerpost more nicely adapted to this purpose, if the thing can be made manifest with bicoloured lights. Fix a lighted wax taper in a small metal stand ; place the stand in the middle of a bowl, and pour round it spirit of wine, but not enough to reach the top of the stand. Then set fire to the spirit of wine. The spirit of wine will yield a blueish, the taper a yellow flame. Observe therefore whether the flame of the taper (which is easily distinguished by its colour from the flame of the spirit of wine, since flames do not mix at once, as liquids do) remains in a conical or rather tends to a globular form, now that there is nothing to destroy or compress it [81]. If the latter is found to be the case, it may be set down as certain that flame remains numerically identical as long as it is enclosed within other flame and feels not the antagonistic action of the air.

Let this suffice for Instances of the Fingerpost. I have dwelt on them at some length, to the end that men may gradually learn and accustom themselves to judge of nature by Instances of the Fingerpost and Experiments of Light, and not by probable reasonings.

XXXVII.

Among Prerogative Instances I will put in the fifteenth place *Instances of Divorce ;* which indicate the separation of natures of most familiar occurrence. They differ from the instances subjoined to the Instances of Companionship, in that the latter indicate the separation of a nature from some concrete substance with which it is ordinarily in conjunction, while these instances indicate the separation of one nature from another. They differ from Instances of the Fingerpost, in that they determine nothing, but simply notify the separability of one

[80] It is well known that the expansive force of the vapour of mercury at high temperatures is enormous.

[81] This experiment is mentioned as actually *tried* in *Sylva Sylvarum*, 31.

nature from another. Their use is to detect false forms, and to dissipate slight theories suggested by what lies on the surface, and so serve as ballast to the understanding.

For example, let the natures investigated be those four natures which Telesius accounts as messmates and chamber-fellows [82]; namely, Heat, Brightness, Rarity, Mobility or promptness to motion. We find however many Instances of Divorce between them. For air is rare and mobile, not hot or bright; the moon is bright without heat; boiling water is hot without light; the motion of an iron needle on a pivot is quick and nimble, and yet the body is cold, dense and opaque; and there are many more of the kind.

Again, let the natures investigated be Corporeal Nature and Natural Action. For it seems that natural action is not found except as subsisting in some body. Yet in this case also we shall perhaps be able to find some Instance of Divorce; such, for example, as magnetic action, by which iron is drawn to the magnet, heavy bodies to the globe of the earth. There may also be added some other operations performed at a distance. For such action takes place both in time, occupying moments not a mere instant of time; and in space, passing through degrees and distances. There is therefore some moment of time, and some distance of space, in which the virtue or action remains suspended between the two bodies which produce the motion. The question therefore is brought to this; whether the bodies which are the limits of the motion dispose or alter the intermediate bodies, so that by a succession of actual contacts the virtue passes from limit to limit, meanwhile subsisting in the intermediate body; or whether there is no such thing, but only the bodies, the virtue, and the distances. In rays of light indeed, and sounds, and heat, and certain other things acting at a distance it is probable that the intermediate bodies are disposed and altered; the more so, because they require a medium qualified for carrying on the operation. But that magnetic or attractive virtue admits of media without distinction, nor is the virtue impeded in any kind of medium. And if the virtue or action has nothing to do with the intermediate body, it follows that there is a natural virtue or action subsisting for a certain time and in a certain space without a body; since it neither subsists in the limiting nor in the intermediate bodies. And therefore magnetic action may be an Instance of Divorce between corporeal nature and natural action. To which may be appended as a corollary or advantage not to be omitted, that here is a proof furnished by merely human philosophy of the existence of essences and substances separate from matter and incorporeal. For allow that a natural virtue and action, emanating from a body, can exist for a certain time and in a certain space altogether without a body, and you are not far from allowing that it can also emanate originally from an incorporeal substance. For corporeal nature appears to be no less requisite for sustaining and conveying natural action, than for exciting or generating it.

XXXVIII.

Now follow five classes of instances which under one general name I call *Instances of the Lamp*, or *of First Information*. They are those which aid the senses. For since all Interpretation of Nature commences with the senses, and leads from the perceptions of the senses by a straight, regular, and guarded path to

[82] The fundamental idea of Telesius's philosophy is, that heat and cold are the great constituent principles of the universe, and that the antithesis between them corresponds to that which he recognises between the sun and the earth:—"Omnino calidus, tenuis, candidus, mobilisque est Sol; Terra contra frigida, crassa, immobilis, tenebricosaque . . . unum Sol in terram emittens calorem ejus naturam facultatesque et conditiones ex eâ deturbat omnes, suasque ei indit; et eodem ferme modo quo Sol terram, etiam calor quivis, vel qui e commotis contritisque enascitur rebus, quæ corripit exuperatque immutare videtur; frigus scilicet ex iis, ejusque facultates conditionesque omnes, crassitiem, obscuritatem, immobilitatem, deturbare, et se ipsum iis, propriasque facultates conditionesque omnes, tenuitatem, albedinem et mobilitatem, indere . . . . videtur."—*De Rerum Naturâ*, i. c. 1.

the perceptions of the understanding, which are true notions and axioms, it follows of necessity that the more copious and exact the representations of the senses, the more easily and prosperously will everything proceed.

Of these five Instances of the Lamp, the first strengthen, enlarge, and rectify the immediate actions of the senses ; the second make manifest things which are not directly perceptible by means of others which are ; the third indicate the continued processes or series of those things and motions which are for the most part unobserved except in their end or periods ; the fourth provide the sense with some substitute when it utterly fails ; the fifth excite the attention and notice of the sense, and at the same time set bounds to the subtlety of things. Of these I shall now speak in their order.

XXXIX.

Among Prerogative Instances I will put in the sixteenth place *Instances of the Door or Gate*, this being the name I give to instances which aid the immediate actions of the senses. Now of all the senses it is manifest that sight has the chief office in giving information. This is the sense therefore for which we must chiefly endeavour to procure aid. Now the aids to sight are of three kinds ; it may be enabled to perceive objects that are not visible ; to perceive them further off ; and to perceive them more exactly and distinctly.

Of the first kind (not to speak of spectacles and the like, which serve only to correct or relieve the infirmity of a defective vision, and therefore give no more information) are those recently invented glasses which disclose the latent and invisible minutiæ of bodies, and their hidden configurations and motions, by greatly increasing their apparent size ; instruments by the aid of which the exact shape and outline of body in a flea, a fly, a worm, and also colours and motions before unseen, are not without astonishment discerned. It is also said [83] that a straight line drawn with a pen or pencil is seen through such glasses to be very uneven and crooked ; the fact being that neither the motion of the hand, though aided by a ruler, nor the impression of the ink or colour, is really even ; although the unevenness is so minute that it cannot be detected without such glasses. And here (as is usual in things new and wonderful) a kind of superstitious observation has been added ; viz. that glasses of this sort do honour to the works of nature, but dishonour to the works of art [84]. The truth however is only this, that natural textures are far more subtle than artificial. For the microscope, the instrument I am speaking of, is only available for minute objects ; so that if Democritus had seen one, he would perhaps have leaped for joy, thinking a way was now discovered of discerning the atom, which he had declared to be altogether invisible [85]. The incompetency however of such glasses, except for minutiæ alone, and even for them when existing in a body of considerable size, destroys the use of the invention. For if it could be extended to larger bodies, or to the minutiæ of larger bodies, so that the texture of a linen cloth could be seen like network, and thus the latent minutiæ and inequalities of gems, liquors, urine, blood, wounds, &c. could be distinguished, great advantages might doubtless be derived from the discovery.

Of the second kind are those other glasses discovered by the memorable efforts of Galileo, by the aid of which, as by boats or vessels, a nearer intercourse with the heavenly bodies can be opened and carried on. For these show us that the milky way is a group or cluster of small stars entirely separate and distinct ; of which

[83] Compare *Aph.* xiii. § 28. It would appear from the passage in the text that Bacon had not even seen one of the newly invented microscopes.—*J. S.*

[84] Leibnitz goes as far as to say, "La matière arrangée par une sagesse divine doti être essentiellement organisée partout ; . . . il y a machine dans les parties de la machine naturelle à l'infini".—*Sur le Principe de Vie*, p. 431 of Erdmann's edition.

[85] Democritus maintained that the atom was wholly incognisable by the senses. Thus Sextus Empiricus mentions him along with Plato as having held the doctrine. μόνα τὰ νοητὰ ἀληθῆ εἶναι ; the reason in the case of Democritus being that his atoms, which alone he recognised as realities, possessed πάσης αἰσθητῆς ποιότητος ἔρημον φύσιν. —Sext. Emp. *Advers. Logicos*, ii. § 6.

fact there was but a bare suspicion among the ancients. They seem also to point out that the spaces of the planetary orbits, as they are called, are not altogether destitute of other stars, but that the heaven begins to be marked with stars before we come to the starry sphere itself; although with stars too small to be seen without these glasses. With this instrument we can descry those small stars wheeling as in a dance round the planet Jupiter; whence it may be conjectured that there are several centres of motion among the stars. With this the inequalities of light and shade in the moon are more distinctly seen and placed; so that a sort of selenography can be made. With this we descry spots in the sun, and similar phenomena; all indeed noble discoveries, so far as we may safely trust to demonstrations of this kind; which I regard with suspicion chiefly because the experiment stops with these few discoveries, and many other things equally worthy of investigation are not discovered by the same means [86].

Of the third kind are measuring rods, astrolabes, and the like; which do not enlarge the sense of sight, but rectify and direct it. And if there are other instances which aid the remaining senses in their immediate and individual actions, and yet are of a kind which add nothing to the information already possessed, they are not to the present purpose; and therefore I have omitted to mention them.[87]

XL

Among Prerogative Instances I will put in the seventeenth place *Summoning Instances*, borrowing the name from the courts of law; because they summon objects to appear which have not appeared before; I also call them *Evoking Instances*. They are those which reduce the non-sensible to the sensible; that is, make manifest things not directly perceptible by means of others which are.

An object escapes the senses, either on account of its distance; or on account of the interposition of intermediate bodies; or because it is not fitted for making an impression on the sense; or because it is not sufficient in quantity to strike the sense; or because there is not time enough for it to act on the sense; or because the impression of the object is such as the sense cannot bear; or because the sense has been previously filled and occupied by another object, so that there is not room for a new motion. These cases have reference principally to the sight and secondarily to the touch. For these two senses give information at large and concerning objects in general; whereas the other three give no information hardly, but what is immediate and relates to their proper objects.

In the first kind, where an object is imperceptible by reason of its distance, there is no way of manifesting it to the sense but by joining to it or substituting for it some other object which may challenge and strike the sense from a greater distance; as in communication by beacons, bells, and the like.

[86] Galileo often mentions the attempt which many of the Peripaticians made to set aside all arguments founded on his discoveries with the telescope, by saying that they were mere optical delusions. J. C. La Galla, in his dissertation *De Phænominis in Orbe Lunæ*, has a section entitled "De Telescopii Veritate", in which, though an Aristotelian, he has nevertheless admitted that this objection is untenable.

[87] Compare this with the passage in the *Descriptio Globi Intellectualis* (c. v.) where Bacon speaks of Galileo's invention and discoveries (the firstfruits of which had just been announced) in a strain of more sanguine expectation. From that passage, written eight years before, we may learn (I think) why it was that Bacon had now begun to doubt how far these observations could be trusted. Believing as he did that all the received theories of the heavens were full of error, as soon as he heard that by means of the telescope men could really see so much further into the heavens than before, he was prepared to hear of a great number of new and unexpected phenomena; and his only fear was that the observers, instead of following out their observations patiently and carefully, would begin to form new theories. But now that nine years had passed since the discovery of Jupiter's satellites, the spots in the sun, etc., and no new discovery of importance had been announced, he wondered how it could be that men seeing so much further should be able to see so little more than they did, and began to suspect that it was owing to some defect either in the instrument or in the methods of observation.—*J. S.*

In the second kind, this reduction or secondary manifestation is effected when objects that are concealed by the interposition of bodies within which they are enclosed, and cannot conveniently be opened out, are made manifest to the sense by means of those parts of them which lie on the surface, or make their way from the interior. Thus the condition of the human body is known by the state of the pulse, urine, and the like.

In the third and fourth kind, reductions are applicable to a great many things, and in the investigations of nature should be sought for on all sides. For example, it is obvious that air and spirit, and like bodies, which in their entire substance are rare and subtle, can neither be seen nor touched. Therefore in the investigation of bodies of this kind, it is altogether necessary to resort to reductions.

Thus let the nature in question be the Action and Motion of the Spirit enclosed in tangible bodies. For everything tangible that we are acquainted with contains an invisible and intangible spirit, which it wraps and clothes as with a garment. Hence that three-fold source, so potent and wonderful, of the process of the spirit in a tangible body. For the spirit in a tangible substance, if discharged, contracts bodies and dries them up; if detained, softens and melts them; if neither wholly discharged nor wholly detained, gives them shape, produces limbs, assimilates, digests, ejects, organises, and the like. And all these processes are made manifest to the sense by conspicuous effects.

For in every tangible inanimate body the enclosed spirit first multiplies itself, and as it were feeds upon those tangible parts which are best disposed and prepared for that purpose; and so digests and elaborates and turns them into spirit; and then they escape together. Now this elaboration and multiplication of the spirit is made manifest to the sense by diminution of weight. For in all desiccation there is some decrease of quantity; not only of the quantity of spirit previously existing in the body, but also of the body itself, which was before tangible and is newly changed; for spirit is without weight. Now the discharge or emission of the spirit is made manifest to the sense in the rust of metals and other similar putrefactions, which stop short before they come to the rudiments of life; for these belong to the third kind of process. For in compact bodies the spirit finds no pores or passages through which to escape, and is therefore compelled to push and drive before it the tangible parts themselves, so that they go out along with it; whence proceed rust and the like. On the other hand the contraction of the tangible parts, after some of the spirit is discharged (upon which desiccation ensues), is made manifest to the sense not only by the increased hardness of the body, but much more by the rents, contractions, wrinklings, and shrivellings, in the body which thereupon take place. For the parts of wood split asunder and are contracted; skins shrivel; and not only that, but if the spirit is suddenly discharged by the heat of fire, they hasten so fast to contraction as to curl and roll themselves up.

On the contrary, where the spirit is detained, and yet expanded and excited by heat or something analogous thereto (as happens in the more solid or tenacious bodies), then are bodies softened, as iron white hot; or they become fluid, as metals; or liquid, as gums, wax, and the like. Thus the contrary operations of heat, which hardens some substances and melts others, are easily reconciled; since in the former the spirit is discharged, in the latter it is excited and detained; whereof the melting is the proper action of the heat and spirit; the hardening is the action of the tangible parts only on occasion of the discharge of the spirit.

But when the spirit is neither wholly detained nor wholly discharged, but only makes trials and experiments within its prison-house, and meets with tangible parts that are obedient and ready to follow, so that whithersoever the spirit leads they go along with it, then ensues the forming of an organic body, and the development of organic parts, and all the other vital actions as well in vegetable as in animal substances. And these operations are made manifest to the sense chiefly by careful observation of the first beginnings and rudiments or essays of life in animalculæ generated from putrefaction; as in ants' eggs, worms, flies, frogs after rain, etc. There is required however for the production of life both mildness in the heat and pliancy in the substance, that the spirit may neither be so hurried

as to break out, nor be confined by the obstinacy of the parts ; but may rather be able to mould and model them like wax.

Again, that most noble distinction of spirit which has so many applications (viz. spirit cut off ; spirit simply branching ; spirit at once branching and cellulate ; of which the first is the spirit of all inanimate substances, the second of vegetables, the third of animals), is brought as it were before the eyes by several instances of this kind of reduction.

In like manner it appears that the more subtle textures and configurations of things (though the entire body be visible or tangible) are perceptible neither to the sight nor touch. And therefore in these also our information comes by way of reduction. Now the most radical and primary difference between configurations is drawn from the abundance or scantiness of the matter occupying the same space or dimensions. For all other configurations (which have reference to the dissimilarity of the parts contained in the same body, and to their collocation and position) are but secondary in comparison with the former.

Thus let the nature in question be the Expansion or Coition of Matter in bodies compared one with another ; viz. how much matter occupies how much space in each. For there is nothing more true in nature than the twin propositions, that " nothing is produced from nothing," and " nothing is reduced to nothing," but that the absolute quantum or sum total of matter remains unchanged, without increase or diminution.[88] Nor is it less true that of that quantum of matter more or less is contained under the same space or dimensions according to the diversity of bodies ; as in water more, in air less ; so that to assert that a given volume of water can be changed into an equal volume of air is as much as to say that something can be reduced to nothing ; as on the other hand to maintain that a given volume of air can be turned into an equal volume of water, is the same as to say that something can be produced out of nothing. And it is from this abundance and scantiness of matter, that the abstract notions of Dense and Rare, though variously and promiscuously used, are properly speaking derived. We must also take for granted a third proposition which is also sufficiently certain ; viz. that this greater or less quantity of matter in this or that body is capable of being reduced by comparison to calculation and to exact or nearly exact proportions. Thus one would be justified in asserting that in any given volume of gold there is such an accumulation of matter, that spirit of wine, to make up an equal quantity of matter, would require twenty-one times the space occupied by the gold.

Now the accumulation of matter and its proportions are made manifest to the sense by means of weight. For the weight answers to the quantity of matter, in the parts of a tangible body ; whereas spirit and the quantum of matter which it contains cannot be computed by weight ; for it rather diminishes the weight than increases it. But I have drawn up a very accurate Table on this subject ; in which I have noted down the weights and volumes of all the metals, the principal stones, woods, liquors, oils, and many other bodies as well natural as artificial ; a thing of great use in many ways, as well for light of information as for direction in practice ; and one that discloses many things quite beyond expectation. Not the least important of which is this—it shows that all the variety in tangible bodies known to us (such bodies I mean as are tolerably compact and not quite spongy and hollow, and chiefly filled with air) does not exceed the limit of the ratio of 1 to 21 :—so limited is nature, or at any rate that part of it with which we have principally to do.

I have also thought it worth while to try whether the proportions can be calculated which intangible or pneumatic bodies bear to bodies tangible. This I attempted by the following contrivance. I took a glass phial, capable of holding about an ounce ; using a small vessel, that less heat might be required to produce evaporation. This phial I filled with spirit of wine almost to the neck ; selecting spirit of wine, because I found by the former Table that of all tangible bodies (which are well united and not hollow) this is the rarest, and contains the least

[88] It is worth remarking that Bacon here asserts as absolutely certain a maxim which is assuredly no result of experience. The same doctrine is as distinctly though not so emphatically asserted by Telesius, I. c. 5.

quantity of matter in a given space. After that, I noted exactly the weight of the spirit and phial together. I then took a bladder, capable of holding about a quart; from which I squeezed out, as well as I could, all the air, until the two sides of the bladder met. The bladder I had previously rubbed over gently with oil, to make it closer; and having thus stopped up the pores, if there were any, I inserted the mouth of the phial within the mouth of the bladder, and tied the latter tightly round the former with a thread, smeared with wax in order that it might stick more closely and tie more firmly. After this I set the phial on a chafing dish of hot coals. Presently the steam or breath of the spirit of wine, which was dilated and rendered pneumatic by the heat, began gradually to expand the bladder, and swelled it out on all sides like a sail. When this took place, I immediately took the glass off the fire placing it on a carpet, that it might not crack with the cold; at the same time making a hole in the bladder, lest the steam should turn liquid again on the cessation of the heat, and so disturb the calculations. I then removed the bladder, and weighing the spirit of wine which remained, computed how much had been converted into steam or air. Then comparing the space which the body had occupied while it was spirit of wine in the phial, with the space which it afterwards occupied when it had become pneumatic in the bladder, I computed the results; which showed clearly, that the body had acquired by the change a degree of expansion a hundred times greater that it had had before.

Again, let the nature in question be Heat or Cold, in a degree too weak to be perceptible to the sense. These are made manifest to the sense by a calendar glass such as I have described above. For the heat and cold are not themselves perceptible to the touch, but the heat expands the air, and the cold contracts it. Nor again is this expansion and contraction of the air perceptible to the sight; but the expansion of the air depresses the water, the contraction raises it; and so at last is made manifest to the sight; not before, nor otherwise.

Again, let the nature in question be the Mixture of Bodies; viz. what they contain of water, oil, spirit, ash, salt, and the like; or (to take a particular instance) what quantity of butter, curd, whey, etc., is contained in milk. These Mixtures, so far as relates to tangible elements, are made manifest to the sense by artificial and skilful separations. But the nature of the spirit in them, though not immediately perceived, is yet discovered by the different motions and efforts of the tangible bodies in the very act and process of their separation; and also by the acridities and corrosions, and by the different colours, smells, and tastes of the same bodies after separation. And in this department men have laboured hard, it is true, with distillations and artificial separations, but not with much better success than in the other experiments which have been hitherto in use; for they have but groped in the dark, and gone by blind ways, and with efforts painstaking rather than intelligent; and (what is worst of all) without attempting to imitate or emulate nature, but rather destroying by the use of violent heats and over-strong powers all that more subtle configuration in which the occult virtues and sympathies of things chiefly reside. Nor do they remember or observe, while making such separations, the circumstance which I have elsewhere pointed out,—namely, that when bodies are tormented by fire or other means, many qualities are communicated by the fire itself, and by the bodies employed to effect the separation, which did not exist previously in the compound; whence strange fallacies have arisen. For it must not be supposed that all the vapour which is discharged from water by the action of fire, was formerly vapour or air in the body of the water; the fact being that the greatest part of it was created by the expansion of the water from the heat of the fire.

So in general, all the nice tests of bodies whether natural or artificial, by which the genuine are distinguished from the adulterated, the better from the viler sort, should be referred to this division; for they make manifest to the sense things not directly perceptible, by means of those which are. They should therefore be sought and collected from all quarters with diligent care.

With regard to the fifth way in which objects escape the sense, it is obvious that the action of sense takes place in motion, and that motion takes place in time. If therefore the motion of any body be either so slow or so quick that it

bears no proportion to the moments which the sense takes to act in, the object is not perceived at all ; as in the motion of the hand of a clock, and again in the motion of a musket ball. Now motion which is too slow to be perceived is easily and usually made manifest to the sense by means of aggregates of motion. Motion which is too quick has not hitherto been competently measured ; and yet the investigation of nature requires that this be done in some cases.

In the sixth kind, where the sense is hindered by the too great power of the object, the reduction may be effected either by removing the object to a greater distance from the sense ; or by deadening its effects by the interposition of a medium which will weaken without annihilating the object ; or by admitting and receiving the reflexion of the object, where the direct impression is too powerful ; as that of the sun for instance in a basin of water.

The seventh cause, where the sense is so charged with one object that it has no room for the admission of another, is almost wholly confined to the sense of smell, and has little to do with the matter in hand. So much then for the reduction of the non-sensible to the sensible,—or the modes of making manifest to the sense things not directly perceptible by means of others which are [89].

Sometimes however the reduction is made not to the sense of a man, but of some other animal, whose sense in some cases is keener than man's ; as of certain scents to the sense of a dog ; of the light which is latent in air when not illumined from without to the sense of a cat, owl, and similar animals, which see in the dark. For Telesius has justly observed, that there is in the air itself a certain original light, though faint and weak, and hardly of any use to the eyes of men and most animals ; inasmuch as animals to whose sense this light is adapted see in the dark, which it is hardly to be believed they do either without light, or by a light within.

Observe also, that at present I am dealing with the deficiencies of the senses and their remedies. The deceptions of the senses must be referred to the particular inquiries concerning sense and the objects of sense ; excepting only that grand deception of the senses, in that they draw the lines of nature with reference to man and not with reference to the universe ; and this is not to be corrected except by reason and universal philosophy.

XLI.

Among Prerogative Instances I will put in the eighteenth place *Instances of the Road ;* which I also call *Travelling Instances* and *Articulate Instances*. They are those which point out the motions of nature in their gradual progress. This class of instances escapes the observation rather than the sense. For it is strange how careless men are in this matter ; for they study nature only by fits and at intervals, and when bodies are finished and completed, not while she is at work upon them. Yet if any one were desirous of examining and studying the contrivances and industry of an artificer, he would not be content with beholding merely the rude materials of the art, and then the completed works ; but would rather wish to be present when the artificer was at his labours and carrying his work on. And a like course should be taken with the investigation of nature. For instance, if we are inquiring into the vegetation of plants, we must begin from the very sowing of the seed, and observe (as we may easily do, by taking out day after day the seeds that have lain in the ground two days, three days, four days, and so on, and carefully examining them) how and when the seed begins to puff and swell, and to be as it were filled with spirit ; secondly, how it begins to burst the skin and put forth fibres, at the same time raising itself slightly upwards, unless the ground

[89] An excellent instance of the "deductio nonsensibilis ad sensibile" [in the second kind] occurs in the experiments recently made by Messrs. Hopkins and Joule for determining the melting-point of substances subjected to great pressure. The substance acted on is enclosed in a tube out of reach and sight. But a bit of magnetized steel has previously been introduced into it, and is supported by it as long as it remains solid. A magnetic needle is placed beside the apparatus, a certain amount of deviation being, of course, produced by the steel within the tube. The moment the temperature reaches the melting-point, the steel sinks ; and its doing so is indicated by the motion of the needle.

be very stiff ; also, how it puts forth its fibres, some for the root downwards, and some for the stem upwards, and sometimes also creeping sideways, if it there finds the ground more open and yielding ; with many other things of the kind. In the same way we should examine the hatching of eggs, in which we might easily observe the whole process of vivification and organisation, and see what parts proceed from the yolk, and what from the white of the egg, and so forth. A similar course should be taken with animals generated from putrefaction[90]. For to prosecute such inquiries concerning perfect animals by cutting out the fœtus from the womb would be too inhuman, except when opportunities are afforded by abortions, the chase, and the like. There should therefore be set a sort of night watch over nature, as showing herself better by night than by day. For these may be regarded as night studies by reason of the smallness of our candle and its continual burning.

The same too should be attempted with inanimate substances ; as I have done myself in investigating the expansion of liquids by fire. For there is one mode of expansion in water, another in wine, another in vinegar, another in verjuice[91], and quite another in milk and oil ; as was easily to be seen by boiling them over a slow fire, and in a glass vessel, in which everything may be clearly distinguished. These matters however I touch but briefly ; meaning to treat of them more fully and exactly when I come to the discovery of the *Latent Process* of things. For it should all along be borne in mind that in this place I am not handling the things themselves, but only giving examples.

XLII.

Among Prerogative Instances I will put in the nineteenth place *Supplementary* or *Substitutive Instances ;* which I also call *Instances of Refuge*. They are those which supply information when the senses entirely fail us ; and therefore we fly to them when appropriate instances are not to be had. Now substitution is made in two ways ; either by gradual approximation or by analogy. To take an example. There is no medium known by the interposition of which the operation of the magnet in drawing iron is entirely prevented. Gold placed between does not stop it, nor silver, nor stone, nor glass, wood, water, oil, cloth or fibrous substances, air, flame, etc. But yet by nice tests some medium may possibly be found to deaden its virtue more than any other ; comparatively, that is, and in some degree. Thus it may be that the magnet would not attract iron as well through a mass of gold, as through an equal space of air, or through ignited silver as well as through cold ; and so in other cases. For I have not made the trial myself in these cases. It is enough to propose such experiments by way of example. Again there is no body we are acquainted with which does not contract heat on being brought near the fire. And yet air contracts heat much more quickly than stone. Such is the Substitution which is made by gradual approximation.

Substitution by analogy is doubtless useful, but is less certain, and should therefore be applied with some judgment. It is employed, when things not directly perceptible are brought within reach of the sense, not by perceptible

[90] The epithet perfecta is generally given to those animals which cannot result from putrefaction. Cæsalpinus, in the *Quæstiones Peripat.* v. 1., maintains that all animals may result from putrefaction, and that this was the doctrine of Aristotle. The same opinion had, I believe, been advanced by Averroës. That mice may be produced by equivocal generation is asserted, as a matter not admitting of dispute, by Cardan, *De Rerum Varietate.* Cæsalpinus refers to the same instance, but less confidently than Cardan. It is worth remarking that Aristotle, though he speaks of the great fecundity of mice, and even of their being impregnated by licking salt, does not mention the possibility of their being produced by putrefaction. (*De Hist. Animal.* vi. 37 ; *Problem.* x 64.) Paracelsus, *De Rerum Generatione,* affirms that all animals produced from putrefaction are more or less venomous. Telesius's opinion is that the more perfect animals cannot result from putrefaction, because the condition of temperature necessary to their production cannot be fulfilled except by means of animal heat.

[91] Wine made of sour grapes (Pliny, xiv. 18, and elsewhere).

operations of the imperceptible body itself, but by observation of some cognate body which is perceptible [92]. For example, suppose we are inquiring into the Mixture of Spirits, which are invisible bodies ; there seems to be a certain affinity between bodies and the matter that feeds or nourishes them. Now the food of flame seems to be oil and fat substances ; of air, water and watery substances ; for flame multiplies itself over exhalations of oil, air over the vapour of water. We should therefore look to the mixture of water and oil, which manifests itself to the sense ; since the mixture of air and flame escapes the sense. Now oil and water, which are mingled together very imperfectly by composition or agitation, are in herbs and blood and the parts of animals, very subtly and finely mingled. It is possible therefore that something similar may be the case with the mixture of flame and air in pneumatic bodies ; which, though not readily mingling by simple commixture, yet seem to be mingled together in the spirits of plants and animals ; especially as all animate spirit feeds on moist substances of both kinds, watery and fat, as its proper food.

Again, if the inquiry be not into the more perfect mixtures of pneumatic bodies, but simply into their composition ; that is, whether they be readily incorporated together ; or whether there be not rather, for example, certain winds and exhalations or other pneumatic bodies which do not mix with common air but remain suspended and floating therein in globules and drops ; and are rather broken and crushed by the air than admitted into or incorporated with it ; this is a thing which cannot be made manifest to the senses in common air and other pneumatic bodies, by reason of their subtlety ; yet how far the thing may take place we may conceive, by way of image or representation, from what takes place in such liquids as quicksilver, oil, or water ; and likewise from the breaking up of air when it is dispersed in water and rises in little bubbles ; and again in the thicker kinds of smoke ; and lastly in dust raised and floating in the air ; in all of which cases no incorporation takes place. Now the representation I have described is not a bad one for the matter in question, provided that diligent inquiry has been first made whether there can be such a heterogeneity in pneumatic bodies as we find there is in liquids ; for if there can, then these images by analogy may not inconveniently be substituted.

But with regard to these Supplementary Instances, although I stated that information was to be derived from them in the absence of instances proper, as a last resource ; yet I wish it to be understood that they are also of great use, even when proper instances are at hand ; for the purpose, I mean, of corroborating the information which the others supply. But I shall treat of them more fully, when I come in due course to speak of the *Supports of Induction*.

XLIII.

Among Prerogative Instances I will put in the twentieth place *Dissecting Instances ;* which I also call *Awakening Instances*, but for a different reason. I call them Awakening, because they awaken the understanding ; Dissecting, because they dissect nature ; for which reason also I sometimes call them *Democritean*. They are those which remind the understanding of the wonderful and exquisite subtlety of nature, so as to stir it up and awaken it to attention and observation and due investigation. Such, for example, as these following : that a little drop of ink spreads to so many letters or lines ; that silver gilt stretches to such a length of gilt wire [93] ; that a tiny worm, such as we find in the skin, possesses in itself both spirit and a varied organization ; that a little saffron tinges

[92] Du Bois Reymond's *Researches in Animal Electricity* give a good example of this. He constructed what may be called an electrical model of a muscle, and succeeded in obtaining an illustration not only of his fundamental result, namely, that any transverse section is negative with respect to any longitudinal one, but also of the more complicated relations between two different portions of the same section.

[93] Dr. Woolaston's method for obtaining wires of extreme fineness was perhaps suggested by the circumstance mentioned in the text. He enclosed a gold wire in a cylinder of silver, drew them out together, and then dissolved away the silver by means of warm nitrous acid.

a whole hogshead of water; that a little civet or musk scents a much larger volume of air; that a little incense raises such a cloud of smoke; that such exquisite differences of sounds, as articulate words, are carried in every direction through the air, and pierce even, though considerably weakened, through the holes and pores of wood and water; and are moreover echoed back, and that too with such distinctness and velocity; that light and colour pass through the solid substances of glass and water so speedily, and in so wide an extent, and with such copious and exquisite variety of images, and are also refracted and reflected; that the magnet acts through bodies of all sorts, even the most compact; and yet (which is more strange) that in all these, passing as they do through an indifferent medium (such as the air is), the action of one does not much interfere with the action of another; that is to say, that at the same time there are carried through spaces of air so many images of visible objects, so many impressions of articulate sound, so many distinct odours, as of a violet, rose, etc.; moreover heat and cold, and magnetic influences; all (I say) at once without impeding one another, just as if they had their own roads and passages set apart, and none ever struck or ran against other.

To these Dissecting Instances it is useful however to subjoin instances which I call Limits of Dissection; as that in the cases above mentioned, though one action does not disturb or impede another action of a different kind; yet one action does overpower and extinguish another action of the same kind; as the light of the sun extinguishes that of a glowworm; the report of a cannon drowns the voice; a strong scent overpowers a more delicate one; an intense heat a milder one; a plate of iron interposed between a magnet and another piece of iron destroys the action of the magnet. But this subject also will find its proper place among the Supports of Induction.

XLIV.

So much for instances which aid the senses; instances which are chiefly useful for the Informative Part of our subject. For information commences with the senses. But the whole business terminates in Works; and as the former is the beginning, so the latter is the end of the matter. I will proceed therefore with the instances which are pre-eminently useful for the Operative Part. They are of two kinds, and seven in number, though I call them all by the general name of *Practical Instances*. In the Operative Part there are two defects, and two corresponding prerogatives of instances. For operation either fails us or it overtasks us. The chief cause of failure in operation (especially after natures have been diligently investigated) is the ill determination and measurement of the forces and actions of bodies. Now the forces and actions of bodies are circumscribed and measured, either by distances of space, or by moments of time, or by concentration of quantity, or by predominance of virtue; and unless these four things have been well and carefully weighed, we shall have sciences, fair perhaps in theory, but in practice inefficient. The four instances which are useful in this point of view I class under one head as *Mathematical Instances* and *Instances of Measurement*.

Operation comes to overtask us, either through the admixture of useless matters, or through the multiplicity of instruments, or through the bulk of the material and of the bodies that may happen to be required for any particular work. Those instances therefore ought to be valued, which either direct practice to the objects most useful to mankind; or which save instruments; or which spare material and provision. The three instances which serve us here, I class together as *Propitious* or *Benevolent Instances*. These seven Instances I will now discuss separately, and with them conclude that division of my subject which relates to the Prerogatives or Rank of Instances.

XLV.

Among Prerogative Instances I will put in the twenty-first place *Instances of the Rod or Rule*; which I also call *Instances of Range* or of *Limitation*. For the powers and motions of things act and take effect at distances, not indefinite or accidental, but finite and fixed; so that to ascertain and observe these dis-

tances in the investigation of the several natures is of the greatest advantage to practice, not only to prevent its failure but also to extend and increase its power. For we are sometimes enabled to extend the range of powers, and as it were to diminish distances ; as for instance by the use of telescopes.

Most of these powers act and take effect only by manifest contact ; as in the impact of two bodies, where the one does not move the other from its place unless they touch each other. Also medicines that are applied externally, as ointments or plasters, do not exert their virtues without touching the body. Finally the objects of the taste and touch do not strike those senses unless they be contiguous to the organs.

There are also powers which act at a distance, though a very small one ; and of these only a few have been hitherto observed, albeit there are many more than men suspect ; as (to take common examples) when amber or jet attracts straws ; bubbles dissolve bubbles on being brought together ; certain purgative medicines draw humours downwards [94], and the like. So too the magnetic power by which iron and a magnet, or two magnets, are made to meet, operates within a fixed but narrow sphere of action ; but if there be any magnetic virtue flowing from the earth (a little below the surface), and acting on a steel needle in respect of its polarity, the action operates at a great distance.

Again, if there be any magnetic power which operates by consent between the globe of the earth and heavy bodies, or between the globe of the moon and the waters of the sea (as seems highly probable in the semimenstrual ebbs and floods [95]), or between the starry sphere and the planets, whereby the latter are attracted to their apogees ; all these must operate at very great distances. There are found also certain materials which catch fire a long way off ; as we are told the naphtha of Babylon does [96]. Heat also insinuates itself at great distances ; as also does cold ; insomuch that by the inhabitants of Canada the masses of ice that break loose and float about the northern ocean, and are borne through the Atlantic towards that coast, are perceived at a great distance by the cold they give out. Perfumes also (though in these there appears to be always a certain corporeal discharge) act at remarkable distances ; as those find who sail along the coasts of Florida, or some parts of Spain, where there are whole woods of lemon and orange and like odoriferous trees, or thickets of rosemary, marjoram, and the like [97]. Lastly the radiations of light and impressions of sound operate at vast distances.

But whether the distances at which these powers act be great or small, it is certain that they are all finite and fixed in the nature of things, so that there is a certain limit never exceeded ; and a limit which depends either on the mass or quantity of matter in the bodies acted on ; or on the strength or weakness of the powers acting ; or on the helps or hindrances presented by the media in which they act ; all which things should be observed and brought to computation. Moreover

[94] Bacon here speaks in accordance with the medical theory in which the brain is the origin and seat of the rheum, which descends from thence and produces disease in other organs—a theory preserved in the word catarrh. Certain purgatives were supposed to draw the rheum down.

[95] It is worth remarking that Galileo speaks contemptuously of the notion that the moon exerts any influence on the tides. His strong wish to explain everything mechanically led him in this instance wrong, as a similar wish has led many others. It arose, not unnaturally, from a reaction against the unsatisfactory explanations which the schoolmen were in the habit of deducing from the specific or occult properties of bodies. Even Leibnitz, in his controversy with Clarke, shows a tendency towards an exclusive preference of a mechanical system of physics, though in other parts of his writings he had spoken favourably of the doctrine of attraction, and though his whole philosophy ought, one would think, to have made him indifferent to the point in dispute. In a system of pre-established harmony, action by contact is as merely apparent as action at a distance.

[96] Strabo, xvi. p. 472. Pliny, ii. § 109.

[97] To the same purpose Milton, *Paradise Lost*, iv. 99 :—

" As when to them who sail
Beyond the Cape of Hope," etc.

the measurements of violent motions (as they are called), as of projectiles, guns, wheels, and the like, since these also have manifestly their fixed limits, should be observed and computed.

There are found also certain motions and virtues of a contrary nature to those which operate by contact and not at a distance; namely, those which operate at a distance and not by contact; and again those which operate more feebly at a less distance, and more powerfully at a greater. The act of sight for instance is not well performed in contact, but requires a medium and a distance. Yet I remember being assured by a person of veracity, that he himself under an operation for the cataract, when a small silver needle was inserted within the first coat of the eye in order to remove the pellicle of the cataract and push it into a corner, saw most distinctly the needle passing over the very pupil. But though this may be true, it is manifest that large bodies are not well or distinctly seen except at the vertex of a cone [98], the rays from the object converging at a certain distance from it. Moreover, old people see objects better at a little distance than if quite close. In projectiles too it is certain that the impact is not so violent at too small a distance as it is a little further off. These therefore and like things should be observed in the measurements of motions with regard to distances.

There is also another kind of local measurement of motions which must not be omitted. This has to do with motions not progressive, but spherical; that is, with the expansion of bodies into a greater sphere or their contraction into a less. For among our measurements of motions we must inquire what degree of compression or extension bodies (according to their nature) easily and freely endure, and at what point they begin to resist, till at last they will bear no more. Thus when a blown bladder is compressed, it allows a certain compression of the air, but if the compression be increased, the air does not endure it, and the bladder bursts.

But this same thing I have tested more accurately by a subtle experiment. I took a small bell of metal, light and thin, such as is used for holding salt, and plunged it into a basin of water, so that it carried down with it the air contained in its cavity to the bottom of the basin; where I had previously placed a small globe, on which the bell was to light. I found then that if the globe was small enough in proportion to the cavity, the air contracted itself into a less space, and was simply squeezed together, not squeezed out. But if it was too large for the air to yield freely, then the air impatient of greater pressure raised the bell on one side, and rose to the surface in bubbles.

Again to test the extension, as well as compression, of which air was susceptible, I had recourse to the following device. I took a glass egg, with a small hole at one end of it, and having drawn out the air through the hole by violent suction, I immediately stopt up the hole with my finger, and plunged the egg into water, and then took away my finger. The air having been extended by the suction and dilated beyond its natural dimensions, and therefore struggling to contract itself again (so that if the egg had not been plunged into the water, it would have drawn in air with a hissing sound), now drew in water in sufficient quantities to allow the air to recover its old sphere or dimension [99].

Now it is certain that the rarer bodies (such as air) allow a considerable degree of contraction, as has been stated; but that tangible bodies (such as water) suffer compression with much greater difficulty, and to a less extent. How far they do suffer it, I have investigated in the following experiment. I had a hollow globe of lead made, capable of holding about two pints, and sufficiently thick to bear considerable force. Having made a hole in it, I filled it with water, and

[98] That is, the eye being at the apex of the visual cone.

[99] This explanation is wholly unsatisfactory. The principle upon which the true explanation depends, namely the pressure of the atmosphere, was, it seems tolerably certain, first suggested by Torricelli. If the experiment were performed in vacuo, no water would enter the egg, unless the egg were plunged to a considerable depth into the water, or unless the vacuum within it were more perfect than could be produced in the manner described.

then stopt up the hole with melted lead, so that the globe became quite solid. I then flattened two opposite sides of the globe with a heavy hammer, by which the water was necessarily contracted into less space; a sphere being the figure of largest capacity. And when the hammering had no more effect in making the water shrink, I made use of a mill or press; till the water impatient of further pressure exuded through the solid lead like a fine dew. I then computed the space lost by the compression, and concluded that this was the extent of compression which the water had suffered; but only when constrained by great violence [100].

But the compression or extension endured by more solid, dry, or more compact bodies, such as wood, stones and metals, is still less than this, and scarcely perceptible. For they free themselves either by breaking, or by moving forward, or by other efforts; as is apparent in the bending of wood or metal, in clocks moving by springs, in projectiles, hammerings, and numberless other motions. And all these things with their measures should in the investigation of nature be explored and set down, either in their certitude, or by estimate, or by comparison, as the case will admit.

XLVI.

Among Prerogative Instances I will put in the twenty-second place *Instances of the Course;* which I also call *Instances of the Water;* borrowing the term from the hourglasses of the ancients, which contained water instead of sand. These measure nature by periods of time, as the Instances of the Rod by degress of space. For all motion or natural action is performed in time; some more quickly, some more slowly, but all in periods determined and fixed in the nature of things. Even those actions which seem to be performed suddenly and (as we say) in the twinkling of an eye, are found to admit of degree in respect of duration.

First then we see that the revolutions of heavenly bodies are accomplished in calculated times; as also the flux and reflux of the sea. The motion of heavy bodies to the earth, and of light bodies towards the heavens, is accomplished in definite periods, varying with the bodies moved and the medium through which they move [101]. The sailing of ships, the movements of animals, the transmission of missiles, are all performed likewise in times which admit (in the aggregate) of measurement. As for heat, we see boys in winter time bathe their hands in flame without being burned, and jugglers by nimble and equable movements turn vessels full of wine or water upside down and then up again, without spilling

[100] This is perhaps the most remarkable of Bacon's experiments; and it is singular that it was so little spoken of by subsequent writers. Nearly fifty years after the publication of the *Novum Organum*, an account of a similar experiment was published by Megalotti, who was secretary of the Accademia del Cimento at Florence; and it has since been familiarly known as the Florentine experiment. I quote his account of it. "Facemmo lavorar di getto una grande ma sottil palla d'argento, e quella ripiena d'acqua raffreddata col ghiaccio serramo con saldissime vite. Di poi cominciammo a martellarla leggiermente per ogni verso, onde ammaccato l'argento (il quale per la sua crudezza non comporta d'assottigliarsi e distendersi come farebbe l'oro raffinato, o il piombo, o altro metallo più dolce) veniva a ristrignersi, e scemare la sua interna capacità, senza che l'acqua patisse una minima compressione, poichè ad ogni colpo si videa trasudare per tutti i pori del metallo a guisa d'argento vivo il quale da alcuna pelle premuto minutamente sprizzasse."—*Saggi di naturali Esperienze fatte nell' Accademia del Cimento*, p. 204. Firenze, 1667. The writer goes on to remark that the absolute incompressibility of water is not proved by this experiment, but merely that it is not to be compressed in the manner described. But the experiment is on other grounds inconclusive.

It is to be remarked that Leibnitz, *Nouveaux Essais*, in mentioning the Florentine experiment, says that the globe was of gold (p. 229, Erdmann), whereas the Florentine academicians expressly say why they preferred silver to either gold or lead.

[101] Galileo had shown, before the year 1592, that the resistance of the air being set aside, all bodies fall with equal velocity. He left Pisa in that year in consequence of the disputes which were occasioned by this refutation of the Aristotelian doctrine, that the velocity is as the weight.

the liquid ; and many other things of a similar kind. The compressions also and expansions and eruptions of bodies are performed, some more quickly, some more slowly, according to the nature of the body and motion, but in certain periods. Moreover in the explosion of several guns at once, which are heard sometimes to the distance of thirty miles, the sound is caught by those who are near the spot where the discharge is made, sooner than by those who are at a greater distance. Even in sight, whereof the action is most rapid, it appears that there are required certain moments of time for its accomplishment ; as is shown by those things which by reason of the velocity of their motion cannot be seen—as when a ball is discharged from a musket. For the ball flies past in less time than the image conveyed to the sight requires to produce an impression.

This fact, with others like it, has at times suggested to me a strange doubt, viz. whether the face of a clear and starlight sky be seen at the instant at which it really exists, and not a little later ; and whether there be not, as regards our sight of heavenly bodies, a real time and an apparent time, just like the real place and apparent place which is taken account of by astronomers in the correction for parallaxes. So incredible did it appear to me that the images or rays of heavenly bodies could be conveyed at once to the sight through such an immense space, and did not rather take a perceptible time in travelling to us. But this suspicion as to any considerable interval between the real time and the apparent afterwards vanished entirely [102], when I came to think of the infinite loss and diminution of quantity which distance causes in appearance between the real body of the star and its seen image ; and at the same time when I observed the great distance (sixty miles at the least) at which bodies merely white are instantly seen here on earth ; while there is no doubt that the light of heavenly bodies exceeds many times over in force of radiation, not merely the vivid colour of whiteness, but also the light of every flame that is known to us. Again the immense velocity in the body itself as discerned in its daily motion (which has so astonished certain grave men that they preferred believing that the earth moved) renders this motion of ejaculation of rays therefrom (although wonderful, as I have said, in speed) more easy of belief. But what had most weight of all with me was, that if any perceptible interval of time were interposed between the reality and the sight, it would follow that the images would oftentimes be intercepted and confused by clouds rising in the meanwhile, and similar disturbances in the medium [103]. And thus much for the simple measures of time.

But not only must we seek the measure of motions and actions by themselves, but much more in comparison ; for this is of excellent use and very general application. Now we find that the flash of a gun is seen sooner than its report is heard ; although the ball must necessarily strike the air before the flame behind it can get out ; and this is owing it seems to the motion of light being more

[102] [It will be observed that, with unlucky ingenuity, Bacon here lets the truth slip from his hands after he has glimpsed it. The Bohn editor notes that Dominic Cassini let it slip in the same way.—Ed.]

[103] I do not know how to understand this passage without attributing to Bacon a confusion of ideas which seems hardly credible. For surely the very thing which he supposes *would* happen if there were a perceptible interval between the *veritas* and the *visus*, that is to say, between the time when a star (for instance) *is* at a given point and the time when we see it there,—in other words, if the image took any time in coming to the eye,—this very thing does actually happen as often as the star is hidden by a cloud or dimmed by a vapour : the species, to use his own word, are intercepted or confused. If indeed, the *force* of the rays were diminished,—and this I suppose would be one consequence of diminished velocity,—the thing would happen more frequently, because there would be more obstructions which they could not overcome : they would be intercepted or confused by media which they now pass through. But the force being the same, and the stream continuous, the *time* of passage could make no difference in this respect. In another respect, namely, the facility of observation, it would make a very great difference ; and it is remarked by Brinkley that, if the velocity of light had been much less than it is, astronomy would have been all but an impossible science. But that is another matter.—*J. S.*

rapid than that of sound. We find too that visible images are received by the sight faster than they are dismissed ; thus the strings of a violin, when struck by the finger, are to appearance doubled or tripled, because a new image is received before the old one is gone ; which is also the reason why rings being spun round look like globes, and a lighted torch, carried hastily at night, seems to have a tail [104]. And it was upon this inequality of motions in point of velocity that Galileo built his theory of the flux and reflux of the sea ; supposing that the earth revolved faster than the water could follow ; and that the water therefore first gathered in a heap and then fell down, as we see it do in a basin of water moved quickly [105]. But this he devised upon an assumption which cannot be allowed, viz. that the earth moves ; and also without being well informed as to the sexhorary motion of the tide.

But an example of the thing I am treating of, to wit, the comparative measures of motions—and not only of the thing itself, but also of its eminent use (of which I spoke just now)—is conspicuous in mining with gunpowder ; where vast masses of earth, buildings, and the like are upset and thrown into the air, by a very small quantity of powder. The cause of which is doubtless this : that the motion of expansion in the impelling powder is quicker many times over than the motion of the resisting gravity ; so that the first motion is over before the counter motion is begun, and thus at first the resistance amounts to nothing. Hence too it happens that in projectiles it is not the strong blow, but the sharp and quick, that carries the body furthest. Nor would it be possible for the small quantity of animal spirit in animals, especially in such huge creatures as the whale or elephant, to bend and guide such a vast mass of body, were it not for the velocity of the spirit's motion, and the slowness of the bodily mass in exerting its resistance.

This one thing indeed is a principal foundation of the experiments in natural magic, of which I shall speak presently ; wherein a small mass of matter overcomes and regulates a far larger mass ; I mean the contriving that of two motions one shall by its superior velocity get the start and take effect before the other has time to act.

Lastly, this distinction of foremost and hindmost ought to be observed in every natural action. Thus in an infusion of rhubarb the purgative virtue is extracted first, the astringent afterwards. And something of the kind I have found on steeping violets in vinegar, where the sweet and delicate scent of the flower is extracted first, and then the more earthy part of the flower, which mars the scent. Therefore, if violets be steeped in vinegar for a whole day, the scent is extracted much more feebly ; but if you keep them in for a quarter of an hour only and then take them out, and (since the scented spirit in violets is small) put in fresh violets every quarter of an hour as many as six times, the infusion is at last so enriched that although there have not been violets in the vinegar, however renewed, for more than an hour and a half altogether, there nevertheless remains in it a most grateful odour, as strong as the violet itself, for an entire

[104] Of the phenomena which he here enumerates Bacon undoubtedly gives the right explanation, though in the case of vibrating strings his explanation is not altogether complete. The distinct or quasi-distinct images to which he refers correspond to limiting positions of the vibrating string.

[105] This account of Galileo's theory of the tides is inaccurate. In this theory the tides are caused by the varying velocity of different points of the earth's surface, arising from the composition of the earth's two motions, namely that about its axis, and that in its orbit. Bacon does not seem to have perceived that both these motions are essential to the explanation. That the earth's being in motion might be the cause of the tides, had been suggested before the time of Galileo by Cæsalpinus in the *Quæstiones Peripateticæ*, iii. 5. It is odd that Patricius, in giving an account of all the theories which had in his time been devised to explain the cause of the tides (see his *Pancosmia*, I. 28.), does not mention Cæsalpinus's, though it was published some years before his own work. Galileo perhaps alludes to Cæsalpinus in his letter to Cardinal Orsino, dated 8th January, 1616. See, for remarks on Cæsalpinus's doctrine, the *Problemata Marina* of Casmann, published in 1596. Casmann's own theory is that of expansion.

year. It should be observed however that the odour does not gather its full strength till after a month from the time of infusion. In the distillation too of aromatic herbs crushed in spirit of wine, it appears that there first rises an aqueous and useless phlegm ; then a water containing more of the spirit of wine ; and lastly, a water containing more of the aroma. And of this kind there are to be found in distillations a great many facts worthy of notice. But let these suffice for examples.

XLVII.

Among Prerogative Instances I will put in the twenty-third place *Instances of Quantity ;* which (borrowing a term from medicine) I also call *Doses of Nature.* These are they which measure virtues according to the *quantity* of the bodies in which they subsist, and show how far the *mode* of the virtue depends upon the *quantity* of the body. And first there are certain virtues, which subsist only in a cosmical quantity ; that is, such a quantity as has consent with the configuration and fabric of the universe. The earth for instance stands fast ; its parts fall. The waters in seas ebb and flow ; but not in rivers, except through the sea coming up. Secondly, almost all particular virtues act according to the greater or less quantity of the body. Large quantities of water corrupt slowly, small ones quickly. Wine and beer ripen and become fit to drink much more quickly in bottles than in casks. If an herb be steeped in a large quantity of liquid, infusion takes place rather than impregnation ; if in a small, impregnation rather than infusion. Thus in its effect on the human body a bath is one thing, a slight sprinkling another. Light dews again never fall in the air, but are dispersed and incorporated with it. And in breathing on precious stones you may see the slight moisture instantly dissolved, like a cloud scattered by the wind. Once more, a piece of a magnet does not draw so much iron as the whole magnet. On the other hand there are virtues in which smallness of quantity has more effect ; as in piercing, a sharp point pierces more quickly than a blunt one ; a pointed diamond cuts glass, and the like.

But we must not stay here among indefinites, but proceed to inquire what *proportion* the Quantity of a Body bears to the Mode of its Virtue. For it would be natural to believe that the one was equal to the other ; so that if a bullet of an ounce weight falls to the ground in a given time, a bullet of two ounces ought to fall twice as quickly ; which is not the fact. Nor do the same proportions hold in all kinds of virtues, but widely different. These measures therefore must be sought from experiment, and not from likelihood or conjecture.

Lastly, in all investigation of nature the quantity of body —the Dose, as it were—required to produce any effect must be set down ; and cautions as to the Too Little and Too Much be interspersed.

XLVIII.

Among Prerogative Instances I will put in the twenty-fourth place *Instances of Strife ;* which I also call *Instances of Predominance.* These indicate the mutual predominance and subjection of virtues ; which of them is stronger and prevails, which of them is weaker and gives way. For the motions and efforts of bodies are compounded, decomposed, and complicated, no less than the bodies themselves. I will therefore first propound the principal kinds of motions or active virtues ; in order that we may be able more clearly to compare them together in point of strength, and thereby to point out and designate more clearly the Instances of Strife and Predominance.

Let the First Motion be that motion of *Resistance* [106] in matter which is inherent in each several portion of it, and in virtue of which it absolutely refuses to be annihilated ; so that no fire, no weight or pressure, no violence, no length of time can reduce any portion of matter, be it ever so small, to nothing ; but it will ever be something, and occupy some space ; and, to whatever straits it may be brought, will free itself by changing either its form or its place ; or if this may not be, will subsist as it is ; and will never come to such a pass as to be either

[106] Orig. *Motus Antitypiæ.* This term was first used by Aristotle.

nothing or nowhere. This motion the Schoolmen (who almost always name and define things rather by effects and incapacities than by inner causes) either denote by the axiom "Two bodies cannot be in one place", or call "The motion to prevent penetration of dimensions". Of this motion it is unnecessary to give examples, as it is inherent in every body.

Let the Second Motion be what I call Motion of *Connexion*; by which bodies do not suffer themselves to be separated at any point from contact with another body; as delighting in mutual connexion and contact. This motion the Schoolmen call "Motion to prevent a vacuum," as when water is drawn up by suction or in a pump; the flesh by cupping-glasses; or when water stops without running out in perforated jars, unless the mouth of the jar be opened to let in the air; and in numberless instances of a similar kind.

Let the Third Motion be what I call Motion of *Liberty*; by which bodies strive to escape from preternatural pressure or tension, and to restore themselves to the dimensions suitable to their nature. Of this motion also we have innumerable examples; such as (to speak first of escape from pressure) the motion of water in swimming, of air in flying, of water in rowing, of air in the undulations of winds, of a spring in clocks; of which we have also a pretty instance in the motion of the air compressed in children's popguns, when they hollow out an alder twig or some such thing, and stuff it up at both ends with a piece of pulpy root or the like, and then with a ramrod thrust one of the roots or whatever the stuffiing be towards the other hole, from which the root at the further end is discharged with a report; and that before it is touched by the nearer root or the ramrod. As for bodies escaping from tension, this motion displays itself in air remaining in glass eggs after suction; in strings, in leather and in cloth, which recoil after tension, unless it has gained too great strength by continuance; and in similar phenomena. This motion the Schoolmen refer to under the name of "Motion in accordance with the form of the Element"; an injudicious name enough, since it is a motion which belongs not only to fire, air and water, but to every variety of solid substance, as wood, iron, lead, cloth, parchment, etc.; each of which bodies has its own proper limit of dimension, out of which it cannot easily be drawn to any considerable extent. But since this Motion of Liberty is of all the most obvious, and is of infinite application, it would be a wise thing to distinguish it well and clearly. For some very carelessly confuse this motion with the two former motions of Resistance and Connexion; the motion, that is, of escape from pressure with the Motion of Resistance; of escape from tension with the Motion of Connexion; just as if bodies when compressed yield or expand, that there may not ensue penetration of dimensions; and, when stretched, recoil and contract, that there may not ensue a vacuum. Whereas if air when compressed had a mind to contract itself to the density of water, or wood to the density of stone, there would be no necessity for penetration of dimensions; yet there might be a far greater compression of these bodies, than they ever do actually sustain. In the same way, if water had a mind to expand to the rarity of air, or stone to the rarity of wood, there would be no need for a vacuum to ensue; and yet there might be effected a far greater extension of these bodies than they ever do actually sustain. Thus the matter is never brought to a penetration of dimensions or to a vacuum, except in the extreme limits of condensation and rarefaction; whereas the motions of which I speak stop far short of these limits, and are nothing more than desires which bodies have for preserving themselves in their consistencies (or, if the Schoolmen like, in their forms), and not suddenly departing therefrom, unless they be altered by gentle means, and with consent. But it is far more necessary (because much depends upon it) that men should know, that violent motion (which we call Mechanical, but which Democritus, who in expounding his primary motions is to be ranked even below second rate philosophers, called Motion of Stripe) is nothing more than this Motion of Liberty, that is, of escape from compression to relaxation. For either in a mere thrust, or in flight through the air, there occurs no movement or change of place, until the parts of the body moved are acted upon and compressed by the impelling body more than their nature will bear. Then indeed, when each part pushes against the next, one after the other,

the whole is moved; and it not only moves forward, but revolves at the same time; the parts seeking in that way also to free themselves or to distribute the pressure more equally. And so much for this Motion.

Let the Fourth Motion be that to which I have given the name of the Motion of *Matter;* which is in some sort the converse of the last-named motion. For in the Motion of Liberty bodies dread, loathe, and shun a new dimension, or a new sphere, or new expansion or contraction (which are all names for the same thing), and strive with all their might to recoil, and recover their old consistency. On the contrary in this Motion of Matter, bodies desire a new sphere or dimension, and aspire thereto readily and quickly, and sometimes, as in the case of gunpowder, with most violent effort. Now the instruments of this motion, not indeed the sole, but the most potent, or at any rate the most common, are heat and cold. For instance; air, if expanded by tension, as by suction in glass eggs, labours under a strong desire to recover itself. But if heat be applied, it longs on the contrary to expand, and desires a new sphere, and passes into it readily, as into a new form (so they phrase it); and after a certain degree of expansion cares not to return, unless invited thereto by the application of cold; which is not a return, but a renewed transmutation. In the same way water, if made to contract by pressure, resists and wishes to become such as it was, that is, larger. But if there intervene intense and continued cold, it changes itself spontaneously and gladly to the density of ice; and if the cold be continued long, without interruption from heat, as in grottoes and caverns of some depth, it turns to crystal [107] or some similar material, and never recovers its form.

Let the Fifth Motion be the Motion of *Continuity;* by which I do not mean simple and primary continuity with some other body (for that is the Motion of Connexion), but self-continuity in a given body. For it is most certain that all bodies dread a solution of continuity; some more, some less, but all to a certain extent. For while in hard bodies, as steel or glass, the resistance to discontinuity is exceedingly strong; even in liquids, where it seems to disappear, or at all events to be very feeble, it is not altogether absent, but is certainly there, though in its lowest degree of power, and betrays itself in very many experiments; as in bubbles, in the roundness of drops, in the thin threads of droppings from roofs, in the tenacity of glutinous bodies, and the like. But most of all does this appetite display itself, if an attempt be made to extend the discontinuity to minute fragments. For in a mortar, after a certain amount of pulverisation the pestle produces no further effect; water does not penetrate into minute chinks; even air itself, notwithstanding its subtlety, does not suddenly pass through the pores of solid vessels, but only after long insinuation.

Let the Sixth Motion be that which I call Motion *for Gain,* or Motion *of Want.* It is that by which bodies, when placed among quite heterogeneous and hostile bodies, if they find an opportunity of escaping from these and uniting themselves to others more cognate, (though these others be such as have no close union with them), do nevertheless embrace the latter and choose them as preferable; and seem to view this connexion in the light of a *gain* (whence the term), as though they stood in need of such bodies. For instance, gold or any other metal in the leaf does not like the surrounding air. If therefore it meet with any thick tangible body, (as a finger, paper, what you will,) it instantly sticks to it and is not easily torn away. So too paper, cloth, and the like do not agree well with the air which is lodged in their pores. They are therefore glad to imbibe water or other moisture and eject the air. A piece of sugar too, or a sponge, if dipped at one end in water or wine, while the other stands out far above the surface, draws the water or the wine gradually upwards.

Hence we derive an excellent rule for opening and dissolving bodies. For (to

[107] Pliny, xxxvii. 9. Also Seneca, *Natural Questions.* Though this account of the origin of crystals is of course erroneous, yet there is a class of crystals which have been shown to occupy the volume which their water of crystallisation would in the state of ice; so that their other constituents may in some sort be said to take up no space. This curious analogy with ice was proved by Playfair and Joule in a very considerable number of cases. See *Phil. Mag.*, Dec. 1845.

say nothing of corrosives and strong waters which open for themselves a way) if there can be found a body proportioned to and more in harmony and affinity with a given solid body, than that with which it is, as of necessity, mixed, the solid body immediately opens and relaxes itself, and shutting out or ejecting the latter, receives the former into itself. Nor does this Motion for Gain act or exist only in immediate contact. For electricity (of which Gilbert and others after him have devised such stories) is nothing else than the appetite of a body when excited by gentle friction—an appetite which does not well endure the air, but prefers some other tangible body, if it be found near at hand.

Let the Seventh Motion be what I call the Motion *of the Greater Congregation ;* by which bodies are carried towards masses of a like nature with themselves ; heavy bodies to the globe of the earth, light to the compass of the heaven. This the Schoolmen have denoted by the name of *Natural Motion ;* from superficial considerations ; either because there was nothing conspicuous externally which could produce such motion (and therefore they supposed it to be innate and inherent in things themselves) ; or perhaps because it never ceases. And no wonder ; for the earth and heaven are ever there, whereas the causes and origins of most other motions are sometimes absent, sometimes present. Accordingly this motion, because it ceases not, but when others cease is felt instantly, they deem perpetual and proper ; all others adscititious. This motion however in point of fact is sufficiently weak and dull, being one which, except in bodies of considerable bulk, yields and succumbs to all other motions, as long as they are in operation. And though this motion has so filled men's thoughts as to have put all others almost out of sight, yet it is but little that they know about it, being involved in many errors with regard to it.

Let the Eighth Motion be the Motion of *the Lesser Congregation ;* by which the homogeneous parts in a body separate themselves from the heterogeneous, and combine together ; by which also entire bodies from similarity of substance embrace and cherish each other, and sometimes are attracted and collected together from a considerable distance ; as when in milk, after it has stood awhile, the cream rises to the top ; while in wine the dregs sink to the bottom. For this is not caused by the motion of heaviness and lightness only, whereby some parts rise up and some sink down ; but much more by a desire of the homogeneous parts to come together and unite in one. Now this motion differs from the Motion of Want in two points. One is that in the latter there is the stronger stimulus of a malignant and contrary nature ; whereas in this motion (provided there be nothing to hinder or fetter it) the parts unite from friendship, even in the absence of a foreign nature to stir up strife. The other point is, that the union is here closer, and as it were with greater choice. In the former, if only the hostile body be avoided, bodies not closely related come together ; whereas in the latter, substances are drawn together by the tie of close relationship, and as it were combine into one. And this motion resides in all composite bodies, and would readily show itself were it not bound and restrained by other appetites and necessities in the bodies, which interfere with the union in question.

Now the binding of this motion takes place generally in three ways ; by the torpor of bodies ; by the check of a dominant body ; and by external motions. Now, for the torpor of bodies, it is certain that there resides in tangible substances a certain sluggishness, more or less, and an aversion from change of place ; insomuch that, unless they be excited, they had rather remain as they are than change for the better. Now this torpor is shaken off by the help of three things ; either by heat, or by the eminent virtue of some cognate body, or by lively and powerful motion. And as for the help of heat, it is for this reason that heat has been defined to be " that which separates Heterogeneous and congregates Homogeneous parts " ; a definition of the Peripatetics justly derided by Gilbert, who says it is much the same as if a man were to be defined as that which sows wheat and plants vines—for that it is a definition simply by effects, and those particular [108]. But the definition has a worse fault ; inasmuch as these effects, such

[108] For the definition we may refer to the *Margarita Philosophiæ*, xi. 3. It is founded on a passage in the *De Gen. et Corr.* ii. 2. Gilbert's censure on it is to be found in his

as they are, arise not from a peculiar property of heat, but only indirectly (for cold does the same, as I shall afterwards show); being caused by the desire of homogeneous parts to unite; heat simply aiding to shake off the torpor which had previously bound the desire. As for the help derived from the virtue of a cognate body, it is well seen in an armed magnet, which excites in iron the virtue of detaining iron by similarity of substance; the torpor of the iron being cast off by the virtue of the magnet. And as for help derived from motion, it is shown in wooden arrows, having their points also of wood, which penetrate more deeply into wood than if they were tipped with steel, owing to the similarity of substance; the torpor of the wood being shaken off by the rapid motion. Of these two experiments I have spoken also in the Aphorism on Clandestine Instances.

That binding of the motion of the Lesser Congregation which is caused by the restraint of a dominant body, is seen in the resolution of blood and urine by cold. For as long as those bodies are filled with the active spirit, which, as lord of the whole, orders and restrains the several parts of whatsoever sort, so long the homogeneous parts do not meet together on account of the restraint; but as soon as the spirit has evaporated, or been choked by cold, then the parts being freed from restraint meet together in accordance with their natural desire. And thus it happens that all bodies which contain an eager spirit (as salts and the like) remain as they are, and are not resolved; owing to the permanent and durable restraint of a dominant and commanding spirit.

That binding of the motion of Lesser Congregation which is caused by external motion, is most conspicuous in the shaking of bodies to prevent putrefaction. For all putrefaction depends on the assembling together of homogeneous parts; whence there gradually ensues the corruption of the old form, as they call it, and the generation of a new. For putrefaction, which paves the way for the generation of a new form, is preceded by a dissolution of the old; which is itself a meeting together of homogeneous parts. That indeed, if not impeded, is simple resolution; but if it be met by various obstacles, there follow putrefactions, which are the rudiments of a new generation. But if (which is the present question) a frequent agitation be kept up by external motion, then indeed this motion of uniting (which is a delicate and tender one, and requires rest from things without) is disturbed and ceases; as we see happen in numberless instances. For example, the daily stirring or flowing of water prevents it from putrefying; winds keep off pestilence in the air; corn turned and shaken in the granary remains pure; all things in short that are shaken outwardly are the slower to putrefy inwardly.

Lastly, I must not omit that meeting of the parts of bodies, which is the chief cause of induration and desiccation. For when the spirit, or moisture turned to spirit, has escaped from some porous body (as wood, bone, parchment, and the like), then the grosser parts are with stronger effort drawn and collected together; whence ensues induration or desiccation; which I take to be owing not so much to the Motion of Connexion, to prevent a vacuum, as to this motion of friendship and union.

As for the meeting of bodies from a distance, that is a rare occurrence, and yet it exists in more cases than are generally observed. We have illustrations of it when bubble dissolves bubble; when medicine draws humours by similarity of substance; when the chord of one violin makes the chord of another sound an

posthumous work *De Mundo nostro sublunari Philosophia nova*, which was published by Gruter in 1651, long after the death of Bacon. It seems, however, as Gruter remarks, that the work, which he suggests may have been written before the treatise *De Magnete*, published in 1600, had been read in manuscript by "viri magni et famæ celeberrimæ". "Illi perspicace in Physicis præsertim ingenio haud pœnitendæ in evolvendo operæ testimonium dederunt, quod integrum excussisse censeantur, et aliqua a vulgaribus opinionibus abhorrentia calculo suo comprobata hinc sparsim citent"; in which I do not doubt that Gruter refers to Bacon. Bacon's quotation seems to have been made from imperfect memory, as the words of the original are:—"quid illud ostendit aut quæ illa differentia ab effectu tantum in quibusdam corporibus, *congregans homogenea et disgregans heterogenea?* ac si diceres hominem animal esse carduos et sentes evellens, et fruges serens, cum istud sit agricolæ studium".—*De Mundo*, etc., i. c. 26.

unison, and the like. I suspect also that this motion prevails in the spirits of animals, though it be altogether unknown. At any rate it exists conspicuously in the magnet and magnetised iron. And now that we are speaking of the motions of the magnet, they ought to be carefully distinguished. For there are four virtues or operations in the magnet, which should not be confounded but kept apart; although the wonder and admiration of men have mixed them up together. The first is, the attraction of magnet to magnet, or of iron to magnet, or of magnetised iron to iron. The second is its polarity, and at the same time its declination. The third, its power of penetrating through gold, glass, stone, everything. The fourth, its power of communicating its virtue from stone to iron, and from iron to iron, without communication of substance. In this place however I am speaking only of the first of these virtues —that is, its attractive power. Remarkable also is the motion of attraction between quicksilver and gold; insomuch that gold attracts quicksilver, though made up into ointments; and men who work amid the vapours of quicksilver usually hold a piece of gold in their mouths, to collect the exhalations which would otherwise penetrate into their skulls and bones; by which also the piece of gold is presently turned white. And so much for the motion of the Lesser Congregation.

Let the Ninth Motion be the *Magnetic;* which, though it be of the same genus with the Motion of the Lesser Congregation, yet if it operates at great distances and on large masses, deserves a separate investigation; especially if it begin not with contact, as most, nor lead to contact, as all motions of congregation do; but simply raise bodies or make them swell, and nothing more. For if the moon raises the waters, or makes moist things swell; if the starry heaven attracts planets to their apogees; if the sun holds Venus and Mercury so that their elongations never exceed a certain distance; these motions seem to fall properly neither under the Greater nor the Lesser Congregation, but to be of a sort of intermediate and imperfect Congregation, and therefore ought to constitute a species by themselves.

Let the Tenth Motion be that of *Flight;* a motion the exact opposite of that of the Lesser Congregation; by which bodies from antipathy flee from and put to flight hostile bodies, and separate themselves from them, or refuse to mingle with them. For although in some cases this motion may seem to be an accident or a consequence of the motion of the lesser congregation, because the homogeneous parts cannot meet without dislodging and ejecting the heterogeneous, still it is a motion that should be classed by itself, and formed into a distinct species, because in many cases the appetite of Flight is seen to be more dominant than the appetite of Union.

This motion is eminently conspicuous in the excretions of animals; and not less in objects odious to some of the senses, especially the smell and the taste. For a fetid odour is so rejected by the sense of smell as to induce by consent in the mouth of the stomach a motion of expulsion; a rough and bitter taste is so rejected by the palate or throat as to induce by consent a shaking of the head and a shudder. But this motion has place in other things also. It is observed in certain forms of reaction; as in the middle region of the air, where the cold seems to be the effect of the rejection of the nature of cold from the confines of the heavenly bodies; as also the great heats and burnings which are found in subterranean places, appear to be rejections of the nature of heat from the inner parts of the earth. For heat and cold, in small quantities, kill one another; but if they be in large masses, and as it were in regular armies, the result of the conflict is that they displace and eject each other in turn. It is also said that cinnamon and other perfumes retain their scent longer when placed near sinks and foul smelling places, because they refuse to come out and mingle with stenches. It is certain that quicksilver, which of itself would reunite into an entire mass, is kept from doing so by spittle, hog's lard, turpentine, and the like; owing to the ill consent which its parts have with such bodies, from which when spread around them they draw back; so that their desire to fly from these intervening bodies is more powerful than their desire of uniting with parts like themselves. And this is called the *mortification* of quicksilver. The fact also that oil does not mix with water is not simply owing to the difference of weight, but to

the ill consent of these fluids; as may be seen from the fact that spirit of wine, though lighter than oil, yet mixes well enough with water. But most of all is the Motion of Flight conspicuous in nitre and such like crude bodies, which abhor flame; as in gunpowder, quicksilver, and gold. But the flight of iron from one pole of the magnet is well observed by Gilbert to be not a Flight strictly speaking, but a conformity and meeting in a more convenient situation [109].

Let the Eleventh Motion be that of *Assimilation*, or of *Self-Multiplication*, or again of simple *Generation*. By which I mean not the generation of integral bodies, as plants or animals, but of bodies of uniform texture. That is to say, by this motion such bodies convert others which are related, or at any rate well disposed to them, into their own substance and nature. Thus flame over vapours and oily substances multiplies itself and generates new flame; air over water and watery substances multiplies itself and generates new air; spirit, vegetable and animal, over the finer parts as well of watery as of oily substance in its food, multiplies itself and generates new spirit; the solid parts of plants and animals, as the leaf, flower, flesh, bone, and the like, severally assimilate new substance to follow and supply what is lost out of the juices of their food. For let no one adopt the wild fancy of Paracelsus, who (blinded I suppose by his distillations) will have it that nutrition is caused only by separation; and that in bread and meat lie eye, nose, brain, liver [110]; in the moisture of the ground, root, leaf, and flower. For as the artist out of the rude mass of stone or wood educes, by separation and rejection of what is superfluous, leaf, flower, eye, nose, hand, foot, and the like; so, he maintains, does Archæus, the internal artist, educe out of food by separation and rejection the several members and parts of our body. But to leave such trifles, it is most certain that the several parts, as well similar as organic, in vegetables and animals do first attract with some degree of selection the juices of their food, which are alike or nearly so for all, and then assimilate them and turn them into their own nature. Nor does this Assimilation or simple Generation take place only in animate bodies, but inanimate also participate therein, as has been stated of flame and air. Moreover, the non-vital spirit, which is contained in every tangible animated substance, is constantly at work to digest the coarser parts and turn them into spirit, to be afterwards discharged; whence ensues diminution of weight and desiccation, as I have stated elsewhere. Nor must we set apart from Assimilation that accretion which is commonly distinguished from alimentation; as when clay between stones concretes and turns into a stony substance, or the scaly substance on the teeth turns into a

[109] Gilbert, *De Magnete*, ii. c. 4.

[110] I have not been able to find any passage in Paracelsus which altogether corresponds to this remark; and in his *Modus Pharmacandi* the process of digestion is described without reference to the Archeus; nor is it said that each member "latet in pane vel cibo." "Hoc scimus, quod cujusque membri nutrimentum latitet in pane, carne, et in aliis similiter." "Quot vero modis et quibus, necnon quâ ratione membris corporis nutrimentum dividatur, nos ignoramus; hoc tantùm scimus, rem ita se habere ut diximus."—*De Mod. Pharm.* v. p. 233. (I use the edition of 1603.)

Bacon has, however, correctly stated the general doctrine that alimentation is by separation; and again Paracelsus affirms that "officium vero Archei est in microcosmo purum ab impuro separare".—*De Morbis Tartareis*, iii. 195. The truth is that Paracelsus's views are so often repeated and varied in the course of his writings, that it is difficult to know how far his opinions are represented by any particular passage.

It is well to remark that, to a certain extent, the theory here so decidedly condemned has, by the recent progress of organic chemistry, been shown to be true. Nothing seems better established than that the nitrogenised components of animal bodies are derived from the corresponding elements of their food. With respect to fat, it is, I believe, a prevailing opinion at present, that animals have the power of converting into it the starch or sugar of their food; and the production of butyric acid by fermentation has been regarded as at least an illustration of the transformation. One of the highest authorities on such a subject, however, I mean M. Boussingault, was, at least a few years ago, of a different opinion. He regarded animal fat as the representative of the fatty matters contained in the food.

substance as hard as the teeth themselves, and so on. For I am of opinion that there resides in all bodies a desire for Assimilation, as well as for uniting with homogeneous substances; but this virtue is bound, as is the other, though not by the same means. But these means, as well as the way of escape from them, ought to be investigated with all diligence, because they pertain to the rekindling of the vital power in old age. Lastly, it seems worthy of observation that in the nine motions of which I have spoken bodies seem to desire only the preservation of their nature, but in this tenth the propagation of it.

Let the Twelfth Motion be that of *Excitation*; a motion which seems to belong to the genus of Assimilation, and which I sometimes call by that name. For it is a motion diffusive, communicative, transitive, and multiplicative, as is the other; and agreeing with it generally in effect, though differing in the mode of effecting and in the subject matter. For the Motion of Assimilation proceeds as it were with authority and command; it orders and forces the assimilated body to turn into the assimilating. But the Motion of Excitation proceeds, so to speak, with art and by insinuation, and stealthily; simply inviting and disposing the excited body to the nature of the exciting. Again, the Motion of Assimilation multiplies and transforms bodies and substances; thus, more flame is produced, more air, more spirit, more flesh. But in the Motion of Excitation, virtues only are multiplied and transferred; more heat being engendered, more magnetic power, more putrefying. This motion is particularly conspicuous in heat and cold. For heat does not diffuse itself, in heating a body, by communication of the original heat, but simply by exciting the parts of the body to that motion which is the Form of Heat; of which I have spoken in the First Vintage concerning the Nature of Heat. Consequently heat is excited far more slowly and with far greater difficulty in stone or metal than in air, owing to the unfitness and unreadiness of those bodies to receive the motion; so that it is probable that there may exist materials in the bowels of the earth which altogether refuse to be heated, because through their greater condensation they are destitute of that spirit with which this Motion of Excitation generally begins. In like manner the magnet endues iron with a new disposition of its parts and a conformable motion, but loses nothing of its own virtue. Similarly leaven, yeast, curd, and certain poisons excite and invite a successive and continued motion in dough, beer, cheese, or the human body, not so much by the force of the exciting as by the predisposition and easy yielding of the excited body [111].

Let the Thirteenth Motion be the Motion of *Impression*; which also is of the same genus with the Motion of Assimilation, and is of diffusive motions the most subtle. I have thought fit however to make a distinct species of it, on account of a remarkable difference between it and the two former. For the simple Motion of Assimilation actually transforms the bodies themselves; so that you may take away the first mover, and there will be no difference in what follows. For the first kindling into flame, or the first turning into air, has no effect on the

[111] The theory here proposed is nearly equivalent to the most recent views on the same subject, as the following passage will sufficiently show.—It is obvious that both statements, however much of truth they may involve, are indefinite and unsatisfactory. It is not said whether the new properties engendered depend upon new types of motion or new arrangements, though the latter is probably Liebig's opinion.

"All the phenomena of fermentation, when taken together, establish the correctness of the principle long since recognised by Laplace and Berthollet, namely, *that an atom or molecule, put in motion by any power whatever, may communicate its own motion to another atom in contact with it.*

"This is a dynamical law of the most general application, manifested everywhere when the resistance or force opposing the motion, such as the vital principle, the force of affinity, electricity, cohesion, etc., is not sufficiently powerful to arrest the motion imparted.

"This law has only recently been recognised as a cause of the alterations in forms and properties which occur in our chemical combinations; and its establishment is the greatest and most enduring acquisition which chemical science has derived from the study of fermentation."—*Liebig's Letters on Chemistry*, p. 209.

flame or air next generated. In like manner, the Motion of Excitation continues, after the first mover is withdrawn, for a very considerable time; as in a heated body, when the primary heat has been removed; in magnetised iron, when the magnet has been put away; in dough, when the leaven has been taken out. But the Motion of Impression, though diffusive and transitive, seems to depend for ever on the prime mover; so that if that be taken away or cease to act, it immediately fails and comes to an end; and therefore the effect must be produced in a moment, or at any rate in a very brief space of time. The Motions therefore of Assimilation and Excitation I call Motions of the *Generation of Jupiter*, because the generation continues; but this, the Motion of the *Generation of Saturn*, because the birth is immediately devoured and absorbed. It manifests itself in three things; in rays of light, in the percussions of sounds, and in magnetism, as regards the communication of the influence. For if you take away light, colours and its other images instantly disappear; if you take away the original percussion and the vibration of the body thence produced, the sound soon after dies away. For though sounds are troubled as they pass through their medium by winds, as if by waves, yet it must be carefully noted that the original sound does not last all the time the resonance goes on. For if you strike a bell, the sound seems to be continued for a good long time; whereby we might easily be led into the error of supposing that during the whole of the time the sound is as it were floating and hanging in the air; which is quite untrue. For the resonance is not the same identical sound, but a renewal of it; as is shown by quieting or stopping the body struck. For if the bell be held tight so that it cannot move, the sound at once comes to an end, and resounds no more; as in stringed instruments, if after the first percussion the string be touched, either with the finger, as in the harp, or with the quill, as in the spinnet, the resonance immediately ceases. Again, when the magnet is removed, the iron immediately drops. The moon indeed cannot be removed from the sea, nor the earth from the falling body, and therefore we can try no experiment in these cases, but the principle is the same.

Let the Fourteenth Motion be the Motion of *Configuration* or *Position*; by which bodies seem to desire not union or separation, but position, collocation and configuration with respect to others. This motion is a very abtruse one, and has not been well investigated. In some cases indeed it seems to be without a cause, though not, I believe, really so. For if it be asked, why the heavens revolve rather from east to west than from west to east; or why they turn on poles placed near the Bears, rather than about Orion, or in any other part of heaven; such questions seem to border on insanity, since these phenomena ought rather to be received as results of observation, and merely positive facts. But though there are no doubt in nature certain things ultimate and without cause, this does not appear to me to be one of them, being caused in my opinion by a certain harmony and consent of the universe, which has not yet fallen under observation [112]. And if we admit the motion of the earth from west to east, the same questions remain. For it also moves on certain poles. And why, it might be asked, should these poles be placed where they are, rather than anywhere else? [113] Again the polarity, direction and declination of the magnet are referable to this motion. There are also found in bodies as well natural as artificial, especially in solids, a certain collocation and position of parts, and a kind of threads and fibres, which ought to be carefully investigated; since, until they are under-

[112] The most striking instance of this kind of harmony is the circumstance that all the movements of the solar system are in the same general direction, viz., from west to east. Laplace has attempted to calculate the probability that this uniformity is the result of a common cause determining the direction of their movements; but these numerical estimations of the probability of the truth of any induction are, on several accounts, altogether unsatisfactory.

[113] This passage shows that Bacon was not aware that the poles are not fixed (collocati) anywhere; in other words, that he was not acquainted with the precession of the equinoxes;—an additional proof how little of his attention had been given to mathematical physics.

stood, these bodies cannot be conveniently managed or controlled. But those eddyings in fluids, by which when pressed, before they can free themselves, they relieve each other, that they may all have a fair share of the pressure, belong more properly to the Motion of Liberty.

Let the Fifteenth Motion be the Motion of *Transition*, or Motion *according to the Passages*; by which the virtues of bodies are more or less impeded or promoted by their media, according to the nature of the body and of the acting virtues, and also of the medium. For one medium suits light, another sound, another heat and cold, another magnetic virtues, and so on.

Let the Sixteenth Motion be the *Royal* (as I call it) or *Political* Motion; by which the predominant and commanding parts in any body curb, tame, subdue and regulate the other parts, and compel them to unite, separate, stand still, move, and range themselves, not in accordance with their own desires, but as may conduce to the well being of the commanding part; so that there is a sort of Government and Polity exerted by the ruling over the subject parts. This motion is eminently conspicuous in the spirits of animals, where, as long as it is in vigour, it tempers all the motions of the other parts. It is found however in other bodies in a lower degree; as I said of blood and urine, which are not decomposed till the spirit, which mixes and keeps together their parts, be discharged or quenched. Nor is this motion confined to spirits, though in most bodies the spirits are masters owing to their rapid and penetrating motion. But in bodies of greater density, and not filled with a lively and quickening spirit (such as there is in quicksilver and vitriol), the thicker parts are the masters; so that unless this yoke and restraint be by some expedient shaken off, there is very little hope of any new transformation of such bodies. But let no one suppose that I am forgetful of the point at issue, because while this series and distribution of motions tends to nothing else but the better investigation of their Predominancy by Instances of Strife, I now make mention of Predominancy among the motions themselves. For in describing this Royal Motion, I am not treating of the Predominancy of motions or virtues, but of the Predominancy of parts in bodies; such being the Predominancy which constitutes the peculiar species of motion in question.

Let the Seventeenth Motion be the *Spontaneous Motion of Rotation*, by which bodies delighting in motion and favourably placed for it enjoy their own nature and follow themselves, not another body; and court (so to speak) their own embraces. For bodies seem either to move without limit, or to remain altogether at rest, or to tend to a limit, at which according to their nature they either revolve or rest. Those which are favourably placed, if they delight in motion, move in a circle; with a motion, that is, eternal and infinite. Those which are favourably placed, and abhor motion, remain at rest. Those which are not favourably placed move in a right line (as the shortest path) to consort with bodies of their own nature [114]. But this Motion of Rotation admits of nine differences; regarding, 1. the centre round which the bodies move; 2. the poles on which they move; 3. their circumference or orbit, according to their distance

[114] This passage is wholly in accordance with the Peripatetic system of physics. But the modifications which Bacon goes on to enumerate, to which, as he conceives, the eternal circular motions of the heavenly bodies may be subject, are sufficient to destroy the whole *à priori* argument in favour of such a system of astronomy as that which we find in the twelfth book of the *Metaphysics*. It has not been sufficiently observed that the Ptolemaic system is no less at variance with the Peripatetic philosophy than the heliocentrical. The attempts of Turrianus and Fracastorius to construct what may be called an orthodox system of astronomy—that is one in which all the motions should take place in circles of which the earth is the centre—was suggested chiefly, as we learn from the *Homocentrica* of the latter, by the wish to reconcile astronomy and philosophy. It had no scientific value, since it left all the phenomena of variations of parallax and apparent diameter unexplained, or, at any rate, gave an explanation of them which no astronomer would accept. It was nevertheless favourably received by the systematic Peripaticians. See, for instance, Flaminius, *De prima Philosoph. Paraph.* p. 119. (I quote the Basle edition of 1557.)

from the centre; 4. their velocity, according to the greater or less rapidity of their rotation; 5. the course of their motion, as from east to west, or from west to east; 6. their declination from a perfect circle by spiral lines more or less distant from their centre; 7. their declination from a perfect circle by spiral lines more or less distant from their poles; 8. the greater or less distance of these spirals from each other; 9. and lastly, the variation of the poles themselves, if they be movable; which however has nothing to do with rotation, unless it be circular [115]. This motion in common and long received opinion is looked upon as the proper motion of heavenly bodies; though there is a grave dispute with regard to it among some both of the ancients and of the moderns, who have attributed rotation to the earth. But a juster question perhaps arises upon this (if it be not past question), namely, whether this motion (admitting that the earth stands still) is confined to the heavens, and does not rather descend and communicate itself to the air and waters. The Motion of Rotation in missiles, as in darts, arrows, musket-balls, and the like, I refer to the Motion of Liberty.

Let the Eighteenth Motion be the Motion of *Trepidation*, to which, as understood by astronomers, I do not attach much credit [116]. But in searching carefully everywhere for the appetites of natural bodies, this motion comes before us, and ought, it seems, to constitute a species by itself. It is a motion of what may be called perpetual captivity, and occurs when bodies that have not quite found their right place, and yet are not altogether uneasy, keep for ever trembling and stirring themselves restlessly, neither content as they are nor daring to advance further. Such a motion is found in the heart and pulses of animals, and must of necessity occur in all bodies which so exist in a mean state between conveniences and inconveniences, that when disturbed they strive to free themselves, and being again repulsed, are yet for ever trying again.

Let the Nineteenth and last Motion be one which, though it hardly answers to the name, is yet indisputably a motion; and let us call it the Motion of *Repose*, or of *Aversion to Move*. It is by this motion that the earth stands still in its mass, while its extremities are moving towards the middle; not to an imaginary centre, but to union. By this appetite also all bodies of considerable density abhor motion; indeed the desire of not moving is the only appetite they have; and though in countless ways they be enticed and challenged to motion, they yet, as far as they can, maintain their proper nature. And if compelled to move they nevertheless seem always intent on recovering their state of rest, and moving no more. While thus engaged indeed they show themselves active, and struggle for it with agility and swiftness enough, as weary and impatient of all delay. Of this appetite, but a partial representation can be seen; since here with us, from the subduing and concocting power of the heavenly bodies, all tangible substances are not only not condensed to their utmost, but are even mixed with some portion of spirit.

Thus then have I set forth the species or simple elements of motions, appetites, and active virtues, which are in nature most general. And under these heads,

[115] I believe the sense is that unless we restrict ourselves to circular motion, that is unless we reject the sixth and seventh species of variation, it will not be necessary for us to suppose the poles themselves to be movable: in other words, that the phenomena of which we could by this hypothesis give an account may be adequately represented without it by means of spirals.

[116] The name of trepidation was given by the Alphonsine astronomers to a motion by which they imagined the starry heaven to be affected, and in virtue of which its equinoxes described small circles of nine degrees radius about those of the ninth or next superior orb. To account for this motion they introduced a tenth orb. The phenomenon, however, thus accounted for was altogether imaginary, although it is true that the length of the tropical year, by supposed variations of which the idea of trepidation was suggested, is not rigorously constant. It may be questioned whether Bacon's hesitation to accept the astronomical motion of trepidation had any better foundation than his doubts whether the proper motions of the planetary orbs were anything more than "res confictæ et suppositæ". The question of the existence or non-existence of trepidation could only be decided by a person conversant with the details of the received system of astronomy.

no small portion of natural science is sketched out. I do not however mean to say that other species may not be added, or that the divisions I have made may not be drawn more accurately according to the true veins of nature, or reduced to a smaller number. Observe nevertheless that I am not here speaking of any abstract divisions; as if one were to say that bodies desire either the exaltation or the propagation or the fruition of their nature; or again, that the motions of things tend to the preservation and good either of the universe, as Resistance and Connexion; or of great wholes, as the Motions of the Greater Congregation, Rotation, and Aversion to Move; or of special forms, as the rest. For though these assertions be true, yet unless they be defined by true lines in matter and the fabric of nature, they are speculative and of little use. Meanwhile these will suffice, and be of good service in weighing the Predominances of Virtues and finding out Instances of Strife; which is our present object.

For of the motions I have set forth some are quite invincible; some are stronger than others, fettering, curbing, arranging them; some carry farther than others; some outstrip others in speed; some cherish, strengthen, enlarge, and accelerate others.

The Motion of Resistance is altogether adamantine and invincible. Whether the Motion of Connexion be so, I am still undecided. For I am not prepared to say for certain whether or no there be a vacuum, either collected in one place or interspersed in the pores of bodies [117]. But of one thing I am satisfied, that the reason for which a vacuum was introduced by Leucippus and Democritus (namely, that without it the same bodies could not embrace and fill sometimes larger and sometimes smaller spaces) is a false one. For matter is clearly capable of folding and unfolding itself in space, within certain limits, without the interposition of a vacuum; nor is there in air two thousand times as much of vacuity as there is in gold; which on their hypothesis there should be [118]. Of this I am sufficiently convinced by the potency of the virtues of pneumatical bodies (which otherwise would be floating in empty space like fine dust), and by many other proofs. As for the other motions, they rule and are ruled in turn, in proportion to their vigour, quantity, velocity, force of projection, and also to the helps and hindrances they meet with.

[117] "Vacuum permistum," *κενὸν ἀχώριστον*, is vacuum diffused through the interstices of any portion of matter. By "vacuum coacervatum," *κενὸν κεχωρισμένον*, is meant clear empty space. See, for this distinction, Aristotle, *Phys.* iv. 7. Hero of Alexandria, whom Bacon mentions more than once, approves of those who admit the former kind of vacuum and reject the latter. See the Introduction to his *Spiritalia*. [It is perhaps worth observing that in the fable entitled: "Cupido sive Atomus (*De Sap. Vet.* xvii.), where the theory of a vacuum is mentioned, this distinction was not introduced till Bacon revised the work in his later years. The passage which stands thus in the original edition (1609)—"Quisquis autem atomum ponit et vacuum, necessario virtutem atomi ad distans introducit"—is altered, in the edition published by Rawley after Bacon's death, to "Quisquis autem atomum asserit atque vacuum (licet istud vacuum intermistum ponat, non segregatum) necessario," etc.—*J. S.*]

[118] "Ex vacuo bis millies" is to be rendered "two thousand times as much of vacuity". Bacon thought spirit of wine a hundred times denser than its own vapour, and gold twenty-one times denser than spirit of wine. In the *Historia Densi et Rari*, he remarks that air is at least a hundred-fold rarer than water; and from the table there given it appears that the specific density of gold is to that of water as 1,000 to 56, nearly. Hence he must have estimated the density of gold at 1900-fold that of air. Now, if we take the same weight of air and of gold, it is clear that, neglecting the space occupied by the solid matter, supposed equally dense, of each, the ratio of their densities is the same as that of the "vacua permista" which they respectively contain, and that if we take the solid matter into account the "ex vacuo" in the case of air must bear a larger ratio than that of the densities to the "ex vacuo" of gold; so that we may take it in round numbers to be as two thousand to one, as in the text.

The passage is important as showing that Bacon, notwithstanding his frequent mention of Democritus, did not adopt the atomic philosophy, though he did not absolutely reject the physical part of it.

For instance, there are some armed magnets that hold and suspend iron of sixty times their own weight; so far does the motion of the Lesser prevail over the motion of the Greater Congregation; but if the weight be increased, it is overcome. A lever of given strength will raise a given weight; so far does the Motion of Liberty prevail over that of the Greater Congregation; but if the weight be increased, it is overcome. Leather stretches to a certain extent without breaking; so far does the Motion of Continuity prevail over the Motion of Tension; but if the tension be increased, the leather breaks, and the Motion of Continuity is overcome. Water runs out at a crack of a certain size; so far does the motion of the Greater Congregation prevail over the Motion of Continuity; but if the crack be smaller, it gives way, and the Motion of Continuity prevails. If you charge a gun with ball and sulphur only, and apply the match, the ball is not discharged; the Motion of the Greater Congregation overcoming in this case the Motion of Matter. But if you charge with gunpowder, the Motion of Matter in the sulphur prevails, being aided by the Motions of Matter and of Flight in the nitre. And so of other cases. Instances of Strife, therefore, which point out the Predominances of Virtues, together with the manner and proportion in which they predominate or give place, should be sought and collected from all quarters with keen and careful diligence.

Nor should we examine less carefully the modes in which these motions give way. That is to say, whether they stop altogether, or whether they continue to resist, but are overpowered. For in bodies here with us there is no real rest, either in wholes or in parts; but only in appearance. And this apparent rest is caused either by equilibrium, or by absolute predominancy of motions; by equilibrium, as in scales, which stand still if the weights be equal; by predominancy, as in watering-pots with holes in them, where the water rests and is kept from falling out by the predominancy of the Motion of Connexion. But it should be observed, as I have said, how far these yielding motions carry their resistance. For if a man be pinned to the ground, tied hand and foot, or otherwise held fast, and yet struggle to rise with all his might, the resistance is not the less, though it be unsuccessful. But the real state of the case (I mean whether by predominancy the yielding motion is, so to speak, annihilated, or whether rather a resistance is continued, though we cannot see it) will perhaps, though latent in the conflicts of motions, be apparent in their concurrence. For example, let trial be made in shooting. See how far a gun will carry a ball straight, or as they say point blank; and then try whether, if it be fired upwards, the stroke will be feebler than when it is fired downwards, where the Motion of Gravity concurs with the blow.

Lastly, such Canons of Predominance as we meet with should be collected, for instance, that the more common the good sought, the stronger the motion. Thus the Motion of Connexion, which regards communion with the universe, is stronger than the Motion of Gravity, which regards only communion with dense bodies. Again, that appetites which aim at a private good seldom prevail against appetites which aim at a more public good, except in small quantities; rules which I wish held good in politics.

XLIX.

Among Prerogative Instances I will put in the twenty-fifth place *Intimating Instances;* those I mean, which intimate or point out what is useful to man. For mere Power and mere Knowledge exalt human nature, but do not bless it. We must therefore gather from the whole store of things such as make most for the uses of life. But a more proper place for speaking of these will be when I come to treat of Applications to Practice. Besides in the work itself of Interpretation in each particular subject, I always assign a place to the *Human Chart*, or *Chart of things to be wished for*. For to form judicious wishes is as much a part of knowledge as to ask judicious questions.

L.

Among Prerogative Instances I will put in the twenty-sixth place *Polychrest Instances* or *Instances of General Use*. They are those which relate to a variety

of cases and occur frequently; and therefore save no small amount of labour and fresh demonstration. Of the instruments and contrivances themselves the proper place for speaking will be when I come to speak of Applications to Practice and Modes of Experimenting. Moreover those which have been already discovered and come into use will be described in the particular histories of the several arts. At present I will subjoin a few general remarks on them as examples merely of this General Use.

Besides the simple bringing together and putting asunder of them, man operates upon natural bodies chiefly in seven ways: viz. either by exclusion of whatever impedes and disturbs; or by compressions, extensions, agitations, and the like; or by heat and cold; or by continuance in a suitable place; or by the checking and regulation of motion; or by special sympathies; or by the seasonable and proper alternation, series, and succession of all these ways, or at any rate of some of them.

With regard to the first; the common air, which is everywhere about us and pressing in, and the rays of the heavenly bodies, cause much disturbance. Whatever therefore serves to exclude them, may justly be reckoned among things of General Use. To this head belong the material and thickness of the vessels in which the bodies are placed on which we are going to operate; also the perfect stopping up of vessels by consolidation and *lutum sapientiæ*, as the chemists call it. Also the closing in of substances by liquids poured on the outside is a thing of very great use; as when they pour oil on wine or juices of herbs, which spreading over the surface like a lid preserves them excellently from the injury of the air. Nor are powders bad things; for though they contain air mixed up with them, they yet repel the force of the body of air round about; as we see in the preservation of grapes and other fruits in sand and flour. It is good too to spread bodies over with wax, honey, pitch, and like tenacious substances, for the more perfect enclosure of them, and to keep off the air and heavenly bodies. I have sometimes tried the effect of laying up a vessel or some other body in quicksilver, which of all substances that can be poured round another is far the densest. Caverns again and subterraneous pits are of great use in keeping off the heat of the sun and that open air which preys upon bodies; and such are used in the North of Germany as granaries. The sinking of bodies in water has likewise the same effect; as I remember to have heard of bottles of wine being let down into a deep well to cool; but through accident or neglect being left there for many years, and then taken out; and that the wine was not only free from sourness or flatness, but much finer tasted; owing, it would seem, to a more exquisite commixture of its parts. And if the case require that bodies be let down to the bottom of the water, as in a river or the sea, without either touching the water or being enclosed in stopped vessels, but surrounded by air alone; there is good use in the vessel which has been sometimes employed for working under water on sunk ships, whereby divers are enabled to remain a long while below, and take breath from time to time. This machine was a hollow bell made of metal, which being let down parallel to the surface of the water, carried with it to the bottom all the air it contained. It stood on three feet (like a tripod) the height of which was somewhat less than that of a man, so that the diver, when his breath failed, could put his head into the hollow of the bell, take breath, and then go on with his work. I have heard also of a sort of machine or boat capable of carrying men under water for some distance [119]. Be that as it may, under such a vessel as I have described bodies of any sort can easily be suspended; and it is on that account that I have mentioned this experiment.

There is also another advantage in the careful and complete closing of bodies; for not only does it keep the outer air from getting in (of which I have already

[119] According to Beckmann, the first distinct mention of the diving-bell, at least in modern times, is to be found in Fainsius, as quoted by Schott. Fainsius gives an account of some Greeks who exhibited a diving-bell at Toledo, before Charles the Fifth and his court, in 1538. [Bacon's words in the text specify in addition to the diving-bell a submarine boat, such as that exhibited by Drebbel in 1620. See below an allusion to the same subject in the *New Atlantis*, and note to the *De Augmentis*, v. 2.—Ed.]

spoken), but also it keeps the spirits of the body, on which the operation is going on inside, from getting out. For it is necessary for one who operates on natural bodies to be certain of his total quantities; that is, that nothing evaporates or flows away. For then, and then only, are profound alterations made in bodies, when, while nature prevents annihilation, art prevents also the loss or escape of any part. On this subject there has prevailed a false opinion, which, if true, would make us well nigh despair of preserving the perfect quantity without diminution; namely, that the spirits of bodies, and air when rarefied by a high degree of heat, cannot be contained in closed vessels, but escape through the more delicate pores. To this opinion men have been led by the common experiment of an inverted cup placed on water with a candle in it or a piece of paper lighted; the consequence of which is that the water is drawn up; and also by the similar experiment of cupping-glasses, which when heated over flame draw up the flesh. For in each of these experiments they imagine that the rarefied air escapes, and that its quantity being thereby diminished, the water or flesh comes up into its place by the Motion of Connexion. But this is altogether a mistake. For the air is not diminished in quantity, but contracted in space; nor does the motion of the rising of the water commence till the flame is extinguished or the air cooled; and therefore physicians, to make their cupping glasses draw better, lay on them cold sponges dipped in water. And therefore there is no reason why men should be much afraid of the easy escape of air or spirits. For though it be true that the most solid bodies have pores, still air or spirit does not eaily submit to such extremely fine comminution; just as water refuses to run out at very small chinks.

With regard to the second of the seven modes of operating above mentioned, it is particularly to be observed, that compression and such violent means have indeed with respect to local motion and the like a most powerful effect; as in machines and projectiles; an effect which even causes the destruction of organic bodies, and of such virtues as consist altogether in motion. For all life, nay all flame and ignition, is destroyed by compression; just as every machine is spoilt or deranged by the same. It causes the destruction likewise of virtues which consist in the position and coarser dissimilarity of parts. This is the case with colours; for the whole flower has not the same colour as when it is bruised, nor the whole piece of amber as the same piece pulverised. So also it is with tastes; for there is not the same taste in an unripe pear as there is in a squeezed and softened one; for it manifestly contracts sweetness by the process. But for the more remarkable transformations and alterations of bodies of uniform structure such violent means are of little avail; since bodies do not acquire thereby a new consistency that is constant and quiescent, but one that is transitory, and ever striving to recover and liberate itself. It would not be amiss however to make some careful experiments for the purpose of ascertaining whether the condensation or the rarefaction of a body of nearly uniform structure (as air, water, oil, and the like), being induced by violence, can be made to be constant and fixed, and to become a kind of nature. This should first be tried by simple continuance, and then by means of helps and consents. And the trial might easily have been made (if it had but occurred to me) when I was condensing water, as mentioned above, by hammer and press, till it burst forth from its enclosure. For I should have left the flattened sphere to itself for a few days, and after that drawn off the water; that so I might have seen whether it would immediately occupy the same dimensions, which it had before condensation. If it had not done so, either immediately or at any rate soon after, we might have pronounced the condensation a constant one; if it had, it would have appeared that a restoration had taken place, and that the compression was transitory. Something of a similar kind I might have tried also with the expansion of air in the glass eggs. For after powerful suction I might have stopped them suddenly and tightly; I might have left the eggs so stopped for some days; and then tried whether on opening the hole the air would be drawn up with a hissing noise; whether on plunging them into water, as much water would be drawn up as there would have been at first without the delay. For it is probable—at least it is worth trying—that this might have been, and may be, the case; since in bodies of

structure not quite so uniform, the lapse of time does produce such effects. For a stick bent for some time by compression does not recoil ; and this must not be imputed to any loss of quantity in the wood through the lapse of time ; since the same will be the case with a plate of steel, if the time be increased, and steel does not evaporate. But if the experiment succeed not with mere continuance, the business must not be abandoned, but other aids must be employed. For it is no small gain if by the application of violence we can communicate to bodies fixed and permanent natures. For thus air can be turned into water by condensation, and many other effects of the kind can be produced ; man being more the master of violent motions than of the rest.

The third of the seven modes above mentioned relates to that which whether in Nature or in Art is the great instrument of operation, viz. heat and cold. And herein man's power is clearly lame on one side. For we have the heat of fire, which is infinitely more potent and intense than the heat of the sun as it reaches us, or the warmth of animals. But we have no cold save such as is to be got in winter time, or in caverns, or by application of snow and ice ; which is about as much perhaps in comparison as the heat of the sun at noon in the torrid zone, increased by the reflexions of mountains and walls ; for such heat as well as such cold can be endured by animals for a short time. But they are nothing to be compared to the heat of a burning furnace, or with any cold corresponding to it in intensity. Thus all things with us tend to rarefaction, and desiccation, and consumption ; nothing hardly to condensation and inteneration, except by mixtures and methods that may be called spurious. Instances of cold therefore should be collected with all diligence ; and such it seems may be found by exposing bodies on steeples in sharp frosts ; by laying them in subterranean caverns ; by surrounding them with snow and ice in deep pits dug for the purpose ; by letting them down into wells ; by burying them in quicksilver and metals ; by plunging them into waters which petrify wood ; by burying them in the earth, as the Chinese are said to do in the making of porcelain, where masses made for the purpose are left, we are told, under ground for forty or fifty years, and transmitted to heirs, as a kind of artificial minerals ; and by similar processes. And so too all natural condensations caused by cold should be investigated, in order that, their causes being known, they may be imitated by art. Such we see in the sweating of marble and stones ; in the dews condensed on the inside of window panes, towards morning, after a night's frost ; in the formation and gathering of vapours into water under the earth, from which springs often bubble up. Everything of this kind should be collected.

Besides things which are cold to the touch, there are found others having the power of cold, which also condense ; but which seem to act on the bodies of animals only, and hardly on others. Of this sort we have many instances in medicines and plasters ; some of which condense the flesh and tangible parts, as astringent and inspissatory medicaments ; while others condense the spirits, as is most observable in soporifics. There are two ways in which spirits are condensed by medicaments soporific, or provocative of sleep ; one by quieting their motion, the other by putting them to flight.. Thus violets, dried rose leaves, lettuce, and like benedict or benignant medicaments, by their kindly and gently cooling fumes invite the spirits to unite, and quiet their eager and restless motion. Rose water too, applied to the nose in a fainting fit, causes the resolved and too relaxed spirits to recover themselves, and as it were cherishes them. But opiates and kindred medicaments put the spirits utterly to flight, by their malignant and hostile nature. And therefore if they be applied to an external part, the spirits immediately flee away from that part, and do not readily flow into it again ; if taken internally, their fumes, ascending to the head, disperse in all directions the spirits contained in the ventricles of the brain ; and these spirits thus withdrawing themselves, and unable to escape into any other part, are by consequence brought together and condensed, and sometimes are utterly choked and extinguished ; though on the other hand these same opiates taken in moderation do by a secondary accident (namely, the condensation which succeeds the coming together) comfort the spirits, and render them more robust, and check their useless and inflammatory motions ; whereby they contribute no little to the cure of diseases, and prolongation of life.

Nor should we omit the means of preparing bodies to receive cold. Among others I may mention that water slightly warm is more easily frozen than quite cold.

Besides, since nature supplies cold so sparingly, we must do as the apothecaries do, who when they cannot get a simple, take its succedaneum or *quid pro quo*, as they call it ; such as aloes for balsam, cassia for cinnamon. In like manner we should look round carefully to see if there be anything that will do instead of cold ; that is to say, any means by which condensations can be effected in bodies otherwise than by cold, the proper office of which is to effect them. Such condensations, as far as yet appears, would seem to be limited to four. The first of these is caused by simple compression, which can do but little for permanent density, since bodies recoil, but which perhaps may be of use as an auxiliary. The second is caused by the contraction of the coarser parts in a body, after the escape of the finer ; such as takes place in indurations by fire, in the repeated quenchings of metals, and like processes. The third is caused by the coming together of those homogeneous parts in a body which are the most solid, and which previously had been dispersed, and mixed with the less solid ; as in the restoration of sublimated mercury, which occupies a far greater space in powder than as simple mercury, and similarly in all purging of metals from their dross. The fourth is brought about through sympathy, by applying substances which from some occult power condense. These sympathies or consents at present manifest themselves but rarely ; which is no wonder, since before we succeed in discovering Forms and Configurations, we cannot hope for much from an inquiry into sympathies. With regard to the bodies of animals indeed, there is no doubt that there are many medicines, whether taken internally or externally, which condense as it were by consent, as I have stated a little above. But in the case of inanimate substances such operation is rare. There has indeed been spread abroad, as well in books as in common rumour, the story of a tree in one of the Tercera or Canary Isles (I do not well remember which) which is constantly dripping ; so as to some extent to supply the inhabitants with water [120]. And Paracelsus says that the herb called *Ros Solis* is at noon and under a burning sun filled with dew, while all the other herbs round it are dry [121]. But both of these stories I look upon as fabulous. If they were true, such instances would be of most signal use, and most worthy of examination. Nor do I conceive that those honey-dews, like manna, which are found on the leaves of the oak in the month of May, are formed and condensed by any peculiar property in the leaf of the oak, but that while they fall equally on all leaves, they are retained on those of the oak, as being well united, and not spongy as most of the others are.

As regards heat, man indeed has abundant store and command thereof ; but observation and investigation are wanting in some particulars, and those the most necessary, let the alchemists say what they will. For the effects of intense heat are sought for and brought into view ; but those of a gentler heat, which fall in most with the ways of nature, are not explored, and therefore are unknown. And therefore we see that by the heats generally used the spirits of bodies are greatly exalted, as in strong waters, and other chemical oils ; that the tangible parts are hardened, and, the volatile being discharged, sometimes fixed ; that the homogeneous parts are separated, while the heterogeneous are in a coarse way incorporated and mixed up together ; above all that the junctures of composite bodies, and their more subtle configurations, are broken up and confounded.

[120] This wonderful tree is described in Johnston's *Dendrographia*, published at Frankort in 1669. See book the tenth, c. 4. One of the authorities he refers to is Cardan (*De variet. rerum*), from whom not improbably Bacon derived the story. The tree is said to be found in the island of Ferro. Cardan, with more than usual caution, remarks, at the close of the account he gives of it : " Sed postquam hoc tot scriptores affirmant, fieri potest ut tale aliquid contingat, sed modus nondum perspectus est".—*De rerum variet.* vi. c. 22. Compare *Oviedo in Ramusio*, iii. 71. a.

[121] I have not been able to find this in Paracelsus. It seems, however, to accord with his theory of dew,—namely that it is an exudation from the sun and stars ; the suppression of which would lead to the formation of additional suns.

Whereas the operations of a gentler heat ought to have been tried and explored, whereby more subtle mixtures and regular configurations might be generated and educed, after the model of nature, and in imitation of the works of the sun ; as I have shadowed forth in the Aphorism on Instances of Alliance. For the operations of nature are performed by far smaller portions at a time, and by arrangements far more exquisite and varied than the operation of fire, as we use it now. And it is then that we shall see a real increase in the power of man, when by artificial heats and other agencies the works of nature can be represented in form, perfected in virtue, varied in quantity, and, I may add, accelerated in time. For the rust of iron is slow in forming, but the turning into *Crocus Martis* is immediate ; and it is the same with verdigris and ceruse ; crystal is produced by a long process, while glass is blown at once ; stones take a long time to grow, while bricks are quickly baked. Meanwhile (to come to our present business), heats of every kind, with their effects, should be diligently collected from all quarters and investigated,—the heat of heavenly bodies by their rays direct, reflected, refracted, and united in burning-glasses and mirrors ; the heat of lightning, of flame, of coal fire ; of fire from different materials ; of fire close and open, straightened and in full flow, modified in fine by the different structures of furnaces ; of fire excited by blowing ; of fire quiescent and not excited ; of fire removed to a greater or less distance ; of fire passing through various media ; moist heats, as of a vessel floating in hot water [122], of dung, of external and internal animal warmth, of confined hay ; dry heats, as of ashes, lime, warm sand ; in short heats of all kinds with their degrees.

But above all, we must try to investigate and discover the effects and operations of heat when applied and withdrawn gradually, orderly, and periodically, at due distances and for due time. For such orderly inequality is in truth the daughter of the heavens, and mother of generation ; nor is anything great to be expected from a heat either vehement or precipitate or that comes by fits and starts. In vegetables this is most manifest ; and also in the wombs of animals there is a great inequality of heat, from the motion, sleep, food and passions of the female in gestation ; lastly in the wombs of the earth itself, those I mean in which metals and fossils are formed, the same inequality has place and force. Which makes the unskilfulness of some alchemists of the reformed school all the more remarkable,—who have conceived that by the equable warmth of lamps and the like, burning uniformly, they can attain their end. And so much for the operations and effects of heat. To examine them thoroughly would be premature, till the Forms of things and the Configurations of bodies have been further investigated and brought to light. For it will then be time to seek, apply, and adapt our instruments, when we are clear as to the pattern.

The fourth mode of operating is by continuance, which is as it were the steward and almoner of nature. Continuance I call it, when a body is left to itself for a considerable time, being meanwhile defended from all external force. For then only do the internal motions exhibit and perfect themselves, when the extraneous and adventitious are stopped. Now the works of time are far subtler than those of fire. For wine cannot be so clarified by fire, as it is by time ; nor are the ashes produced by fire so fine as the dust into which substances are resolved and wasted by ages. So too the sudden incorporations and mixtures precipitated by fire are far inferior to those which are brought about by time. And the dissimilar and varied configurations which bodies by continuance put on, such as putrefactions, are destroyed by fire or any violent heat. Meanwhile it would not be out of place to observe that the motions of bodies when quite shut up have in them

[122] Orig. *Balnei Mariæ*. This is properly " balneum maris ; " that is, a mode of communicating heat to any substance by putting it into a vessel which is placed in another containing water. The latter being put on the fire, the former and its contents become gradually and moderately heated. The reason of the name is obvious. From " balneum maris " the French made by a kind of translation (the final *s* not being sounded) " bain marie ; " and the form in the text is, I think, merely a retranslation of the French phrase, the meaning of the second word being mistaken. Balneum Mariæ is however, I believe, a common phrase with old writers on chemistry.

something of violence. For such imprisonment impedes the spontaneous motions of the body. And therefore continuance in an open vessel is best for separations ; in a vessel quite closed for commixtures ; in a vessel partly closed, but with the air entering, for putrefactions. But indeed instances showing the effects and operations of continuance should be carefully collected from all quarters.

The regulation of motion (which is the fifth mode of operating) is of no little service. I call it regulation of motion, when one body meeting another impedes, repels, admits or directs its spontaneous motion. It consists for the most part in the shape and position of vessels. Thus the upright cone in alembics helps the condensation of vapours ; the inverted cone in receivers helps the draining off of the dregs of sugar. Sometimes a winding form is required, and one that narrows and widens in turn, and the like. For all percolation depends on this, that the meeting body opens the way to one portion of the body met and shuts it to another. Nor is the business of percolation or other regulation of motion always performed from without ; it may also be done by a body within a body ; as when stones are dropped into water to collect its earthy parts ; or when syrups are clarified with the whites of eggs, that the coarser parts may adhere thereto, after which they may be removed. It is also to this regulation of motion that Telesius has rashly and ignorantly enough attributed the shapes of animals, which he says are owing to the channels and folds in the womb[123]. But he should have been able to show the like formation in the shells of eggs, in which there are no wrinkles or inequalities. It is true however that the regulation of motion gives the shapes in moulding and casting.

Operations by consents or aversions (which is the sixth mode) often lie deeply hid. For what are called occult and specific properties, or sympathies and antipathies, are in great part corruptions of philosophy. Nor can we have much hope of discovering the consents of things before the discovery of Forms and Simple Configurations. For consent is nothing else than the adaptation of Forms and Configurations to each other.

The broader and more general consents of things are not however quite so obscure. I will therefore begin with them. Their first and chief diversity is this, that some bodies differ widely as to density and rarity, but agree in configurations, while others agree as to density and rarity but differ in configurations. For it has not been ill observed by the chemists in their triad of first principles, that sulphur and mercury[124] run through the whole universe. (For what they add about salt is absurd, and introduced merely to take in bodies earthy, dry, and fixed.) But certainly in these two one of the most general consents in nature does seem to be observable. For there is consent between sulphur, oil and greasy exhalation, flame, and perhaps the body of a star. So is there between mercury, water and watery vapours, air, and perhaps the pure and intersidereal ether. Yet these two quaternions or great tribes of things (each within its own limits) differ immensely in quantity of matter and density, but agree very well in configuration ; as appears in numerous cases. On the other hand metals agree well together in quantity and density, especially as compared with vegetables, etc., but differ very widely in configuration ; while in like manner vegetables and animals vary almost infinitely in their configurations, but in quantity of matter or density their variation is confined to narrow limits.

The next most general consent is that between primary bodies and their

[123] Telesius's doctrine of the formation of the embryo is essentially the same as Galen's, namely that a system of arteries, etc., must be first of all formed in the germ, and that these, by applying themselves to corresponding parts on the surface of the matrix, determine the channels through which nourishment is supplied, and therefore (mediately) the development of the different members of the fœtus. But it does not seem that he would have admitted that the smoothness of the shells of eggs was an objection to his theory. At any rate, he illustrates it by reference to the appearances presented by an egg opened during incubation. *De rerum naturâ*, vi. c. 4 and 40.

[124] This triad is the fundamental point of Paracelsus's chemical and medical philosophy. See his works throughout, and particularly the tract *De tribus primis essentiis*, contained in the third book of his philosophical works.

supports; that is, their menstrua [125] and foods. We must therefore inquire, under what climates, in what earth, and at what depth, the several metals are generated; and so of gems, whether produced on rocks or in mines; also in what soil the several trees and shrubs and herbs thrive best, and take, so to speak, most delight; moreover what manurings, whether by dung of any sort, or by chalk, sea-sand, ashes, etc., do the most good; and which of them are most suitable and effective according to the varieties of soil. Again, the grafting and inoculating of trees and plants, and the principle of it, that is to say, what plants prosper best on what stocks, depends much on sympathy. Under this head it would be an agreeable experiment, which I have heard has been lately tried, of engrafting forest-trees (a practice hitherto confined to fruit-trees); whereby the leaves and fruit are greatly enlarged, and the trees made more shady. In like manner the different foods of animals should be noted under general heads, and with their negatives. For carnivorous animals cannot live on herbs, whence the order of Feuillans (though the will in man has more power over the body than in other animals) has after trial (they say) well nigh disappeared; the thing not being endurable by human nature [126]. Also the different materials of putrefaction, whence animalculæ are generated, should be observed.

The consents of primary bodies with their subordinates (for such those may be considered which I have noted) are sufficiently obvious. To these may be added the consents of the senses with their objects. For these consents, since they are most manifest, and have been well observed and keenly sifted, may possibly shed great light on other consents also which are latent.

But the inner consents and aversions or friendships and enmities of bodies (for I am almost weary of the words sympathy and antipathy an account of the superstitions and vanities associated with them) are either falsely ascribed,

[125] By "menstrua" are meant the substances out of which any species of mineral is generated, or, in other words, the causa materialis of its existence. See, on the generation of metals and other minerals, the fourth and fifth books of Agricola's work *De ortu et causis fossilium*. He gives an account of the opinions of Aristotle, Theophrastus, etc. In modern chemistry the word menstruum is nearly equivalent to solvent. By the school of Paracelsus the word is used so vaguely that it is difficult to determine what idea they attached to it, or how they derived their sense of the word from its original signification. When the word is used as in the text, the metaphor seems to be taken from the Aristotelian theory of generation, in which *κατὰ τὴν πρώτην ὑλήν ἐστιν ἡ τῶν καταμηνίων φύσις*.

[126] Orig. *Ordo Folitanorum*. Bacon doubtless refers to the order of Feüillans. Jean de la Barrière, after holding the Cistercian abbey of Feüillans in commendam for eleven years, renounced the world in 1573, and in the course of a few years introduced a most austere rule of life into the abbey of which he was the head. His monks knelt on the floor during their refections, and some of them were in the habit of drinking out of skulls. They abstained from eggs, fish, butter, oil, and even salt, and confined themselves to pottage made of herbs boiled in water, and bread so coarse and black that beasts refused to eat of it. After a while they gave up wine also. Clement VIII. permitted the society to draw up constitutions for the establishment of their rule. By these the excessive rigour of their way of life was checked, which was done in obedience to the Pope, and in consequence of the deaths of fourteen monks in a single week at Feüillans. These constitutions were ratified in 1595. Assuming, of which there seems no doubt, that the Folitani of Bacon are the Feüillans, I may remark that the latinised form of Feüillans used is Fuliensis, as an adjective; the proper style of the society being "Congregatio Cistertiomonastica B. Mariæ Fuliensis". I have not seen the work of Morotius to which Helyot, from whom the preceding account is taken, refers, but in that of C. Henrique, also mentioned by Helyot, I do not find any authority for *Folitani*. It is probable that Bacon's chief information on the subject was gathered orally during his residence in France, before the Feüillans had ceased from their first love. The expression "ordo . . . fere evanuit" must be taken to mean that the severe rule that they had at first was given up. See Helyot, *Hist. des Ordres Monastiques*, ivme partie, c. 38. Spondanus, *An.* 1586, iv. For some particulars of the early history of the Abbey of Feüillans, and especially for the will of Jean de la Barrière, see *Voyage Littéraire de deux Bénédictins*, ii. p. 16.

mixed with fables, or from want of observation very rarely met with. For if it be said that there is enmity between the vine and colewort, because when planted near each other they do not thrive; the reason is obvious—that both of these plants are succulent and exhaust the ground, and thus one robs the other. If it be said that there is consent and friendship between corn and the corn-cockle or the wild poppy, because these herbs hardly come up except in ploughed fields; it should rather be said that there is enmity between them, because the poppy and corn-cockle are emitted and generated from a juice in the earth which the corn has left and rejected; so that sowing the ground with corn prepares it for their growth. And of such false ascriptions there is a great number. As for fables, they should be utterly exterminated. There remains indeed a scanty store of consents which have been approved by sure experiment; such as those of the magnet and iron, of gold and quicksilver, and the like. And in chemical experiments on metals there are found also some others worthy of observation, but they are found in greatest abundance (if one may speak of abundance in such a scarcity) in certain medicines, which by their occult (as they are called) and specific properties have relation either to limbs, or humours, or diseases, or sometimes to individual natures. Nor should we omit the consents between the motions and changes of the moon and the affections of bodies below; such as may be gathered and admitted, after strict and honest scrutiny, from experiments in agriculture, navigation, medicine, and other sciences. But the rarer all the instances of more secret consents are, the greater the diligence with which they should be sought after, by means of faithful and honest traditions and narrations; provided this be done without any levity or credulity, but with an anxious and (so to speak) a doubting faith. There remains a consent of bodies, inartificial perhaps in mode of operation, but in use a Polychrest, which should in no wise be omitted, but examined into with careful attention. I mean the proneness or reluctance of bodies to draw together or unite by composition or simple apposition. For some bodies are mixed together and incorporated easily, but others with difficulty and reluctance. Thus powders mix best with water; ashes and lime with oils, and so on. Nor should we merely collect instances of the propensity or aversion of bodies for mixture, but also of the collocation of their parts, of their distribution and digestion when they are mixed, and finally of their predominancy after the mixture is completed.

There remains the seventh and last of the seven modes of operation, namely the means of operating by the alternation of the former sex; but it would not be seasonable to bring forward examples of this, till our search has been carried somewhat more deeply into the others singly. Now a series or chain of such alternations, adapted to particular effects, is a thing at once more difficult to discover, and most effective to work with. But men are utterly impatient both of the inquiry and the practice; though it is the very thread of a labyrinth, as regards works of any magnitude. Let this suffice to exemplify the Polychrest Instances.

LI.

Among Prerogative Instances I will put in the twenty-seventh and last place *Instances of Magic;* by which I mean those wherein the material or efficient cause is scanty or small, as compared with the work and effect produced; so that, even where they are common, they seem like miracles; some at first sight, others even after attentive consideration. These indeed nature of herself supplies sparingly; but what she may do when her folds have been shaken out, and after the discovery of Forms and Processes and Configurations, time will show. But these magical effects (according to my present conjecture) are brought about in three ways; either by self-multiplication, as in fire, and in poisons called specific, and also in motions which are increased in power by passing from wheel to wheel; or by excitation or invitation in another body, as in the magnet, which excites numberless needles without losing any of its virtue, or in yeast and the like; or by anticipation of motion, as in the case already mentioned of gunpowder and cannons and mines. Of which ways the two former require a knowledge of consents; the third, a knowledge of the measurement of motions. Whether

there be any mode of changing bodies *per minima* (as they call it) and of transposing the subtler configurations of matter (a thing required in every sort of transformation of bodies) so that art may be enabled to do in a short time that which nature accomplishes by many windings, is a point on which I have at present no sure indications. And as in matters solid and true I aspire to the ultimate and supreme, so do I for ever hate all things vain and tumid, and do my best to discard them.

LII.

So much then for the Dignities or Prerogatives of Instances. It must be remembered however that in this Organum of mine I am handling logic, not philosophy. But since my logic aims to teach and instruct the understanding, not that it may with the slender tendrils of the mind snatch at and lay hold of abstract notions (as the common logic does), but that it may in very truth dissect nature, and discover the virtues and actions of bodies, with their laws as determined in matter; so that this science flows not merely from the nature of the mind, but also from the nature of things; no wonder that it is everywhere sprinkled and illustrated with speculations and experiments in nature, as examples of the art I teach. It appears then from what has been said that there are twenty-seven Prerogative Instances; namely, Solitary Instances; Migratory Instances; Striking Instances; Clandestine Instances; Constitutive Instances; Conformable Instances; Singular Instances; Deviating Instances; Bordering Instances; Instances of Power; Instances of Companionship and of Enmity; Subjunctive Instances; Instances of Alliance; Instances of the Fingerpost; Instances of Divorce; Instances of the Door; Summoning Instances; Instances of the Road; Instances Supplementary; Dissecting Instances; Instances of the Rod; Instances of the Course; Doses of Nature; Instances of Strife; Intimating Instances; Polychrest Instances; Magical Instances. Now the use of these instances, wherein they excel common instances, is found either in the Informative part or in the Operative, or in both. As regards the Informative, they assist either the senses or the understanding; the senses, as the five Instances of the Lamp; the understanding, either by hastening the Exclusion of the Form, as Solitary Instances;—or by narrowing and indicating more nearly the Affirmative of the Form, as Instances Migratory, Striking, of Companionship, and Subjunctive;—or by exalting the understanding and leading it to genera and common natures; either immediately, as Instances Clandestine, Singular, and of Alliance; or in the next degree, as Constitutive; or in the lowest, as Conformable;—or by setting the understanding right when led astray by habit, as Deviating Instances;—or by leading it to the Great Form or Fabric of the Universe, as Bordering Instances;—or by guarding it against false forms and causes, as Instances of the Fingerpost and of Divorce. In the Operative Part, they either point out, or measure, or facilitate practice. They point it out, by showing with what we should begin, that we may not go again over old ground, as Instances of Power; or to what we should aspire if means be given, as Intimating Instances. The four Mathematical Instances measure practice: Polychrest and Magical Instances facilitate it.

Again out of these twenty-seven instances there are some of which we must make a collection at once, as I said above, without waiting for the particular investigation of natures. Of this sort are Instances Conformable, Singular, Deviating, Bordering, of Power, of the Dose, Intimating, Polychrest, and Magical. For these either help and set right the understanding and senses, or furnish practice with her tools in a general way. The rest need not be inquired into till we come to make Tables of Presentation for the work of the Interpreter concerning some particular nature. For the instances marked and endowed with these Prerogatives are as a soul amid the common instances of Presentation, and as I said at first, a few of them do instead of many; and therefore in the formation of the Tables they must be investigated with all zeal, and set down therein. It was necessary to handle them beforehand because I shall have to speak of them in what follows. But now I must proceed to the supports and rectifications of Induction, and then to concretes, and Latent Processes, and Latent

Configurations, and the rest, as set forth in order in the twenty-first Aphorism; that at length (like an honest and faithful guardian) I may hand over to men their fortunes, now their understanding is emancipated and come as it were of age; whence there cannot but follow an improvement in man's estate, and an enlargement of his power over nature. For man by the fall fell at the same time from his state of innocency and from his dominion over creation. Both of these losses however can even in this life be in some part repaired; the former by religion and faith, the latter by arts and sciences. For creation was not by the curse made altogether and for ever a rebel, but in virtue of that charter, "In the sweat of thy face shalt thou eat bread," it is now by various labours (not certainly by disputations or idle magical ceremonies, but by various labours) at length and in some measure subdued to the supplying of man with bread; that is, to the uses of human life.

END OF THE SECOND BOOK OF THE NEW ORGANUM.

PREPARATIVE TOWARDS A NATURAL AND EXPERIMENTAL HISTORY[1]

PREFACE.

BY JAMES SPEDDING.

AMONG the eight subjects which were to have been handled in the remaining books of the *Novum Organum* (see ii. 21), the last but one is entitled *De parascevis ad inquisitionem*, under which head Bacon intended (as appears by the introduction to the following treatise) to set forth the character of the *Natural and Experimental History*, which was to form the third part of the Instauratio.

What may have been the logical connexion between these eight subjects which determined him to reserve this for the penultimate place, it seems impossible, by the help of the titles alone, to divine. But whatever the order in which he thought advisable to approach it, there can be no doubt that this Natural and Experimental History was always regarded by him as a part of his system both fundamental and indispensable. So earnestly indeed and so frequently does he insist on the importance of it, that I once believed it to be the one real novelty which distinguished his philosophy from those of his contemporaries and immediate predecessors. And even now, though Mr. Ellis's analysis of the Baconian Induction has given me much new light and considerably modified my opinion in that matter, I am still inclined to think that Bacon himself regarded it not only as a novelty, but as *the* novelty from which the most important results were to be expected; and however experience may have proved that his expectations were in great part vain and his scheme impracticable, I cannot help suspecting that more of it is practicable than has yet been attempted, and that the greatest results of science are still to be looked for from a further proceeding in this direction.

The grounds of this opinion will be explained most conveniently in connexion with the following treatise; a treatise published by Bacon (on account of the exceeding importance of the subject) out of its proper place and incomplete; and to which I find nothing among Mr. Ellis's papers that can serve as preface.

In what the distinctive peculiarity of the Baconian philosophy really consisted, is a question to which every fresh inquirer gives a fresh answer. Before I was acquainted with Mr. Ellis's, which is the latest, and formed upon the largest survey and subtlest scrutiny of the evidence, I had endeavoured to find one for myself, and had come to a conclusion which, though quite different from his, is not I think irreconcilable with it, but contains (as I still venture to believe) a part, though a part only, of the truth. And the question which I wish now to raise is whether, as my solution was imperfect from not taking any account of the novelty contained in the *method of Induction* as Bacon understood it, Mr. Ellis's be not likewise imperfect from not taking sufficient account of the novelty contained in the *Natural History* as Bacon intended it to be employed; and whether there be not room for a third solution more complete than either, as including both.

That the philosophy which Bacon meant to announce was in some way essentially different not only from any that had been before but from any that has been

[1] [Translation of *Parasceve ad historiam naturalem et experimentalem.* Published in 1620 in the same volume with the *Novum Organum.*]

since, is a position from which in both cases the inquiry sets out; and since it is one which will not perhaps be readily granted by everybody, it may be worth while to explain the considerations which led me to it; the rather because Mr. Ellis and myself, though proceeding not only independently but by entirely different roads and in pursuit of different objects—he endeavouring to penetrate the secret of Bacon's philosophy, I endeavouring to understand the objects and purposes of his life—meet nevertheless at this point in the same conclusion.

The process by which I arrived at it myself, I cannot explain better than by transcribing a paper which I wrote on the subject in 1847; at which time I had not seen any part of Mr. Ellis's argument, or heard his opinion upon the question at issue. What my own opinion is now, I will state afterwards; but first I give the paper exactly as I then wrote it; the length of the extract being justified—at least if there be any truth in the conclusion—by the importance of the questions at issue; for it bears upon the business of the present and future quite as much as on the knowledge of the past. The form in which it is written,—that of a familiar conversation between two friends,—happened to be the most convenient for the business I was then about; and as I could not present the argument more clearly in any other, I leave it as it is.

A.

Before you go on I wish you would satisfy me on one point, upon which I have hitherto sought satisfaction in vain. What after all was it that Bacon did for philosophy? In what did the wonder and in what did the benefit consist? I know that people have all agreed to call him the Father of the Inductive Philosophy; and I know that the sciences made a great start about his time and have in some departments made great progress since. But I could never yet hear what one thing he discovered that would not have been discovered just as soon without his help. It is admitted that he was not fortunate in any of his attempts to apply his principles to practice. It is admitted that no actual scientific discovery of importance was made by him. Well, he might be the father of discovery for all that. But among all the important scientific discoveries which have been made by others since his time, is there any one that can be traced to his teaching? traced to any principles of scientific investigation originally laid down by him, and by no other man before him or contemporary with him? I know very well that he did lay down a great many just principles;—principles which must have been acted upon by every man that ever pursued the study of Nature with success. But what of that? It does not follow that we *owe* these principles to him. For I have no doubt that I myself,—I that cannot tell how we know that the earth goes round, or why an apple falls or why the antipodes do not fall,—I have no doubt (I say) that if I sat down to devise a course of investigation for the determination of these questions, I should discover a great many just principles which Herschel and Faraday must hereafter act upon, as they have done heretofore. Nay if I should succeed in setting them forth more exactly, concisely, impressively, and memorably, than any one has yet done, they might soon come to be called *my* principles. But if that were all, I should have done little or nothing for the advancement of science. I should only have been finding for some of its processes a better name. I want to know whether Bacon did anything more than this; and if so, what. In what did the principles laid down by him essentially differ from those on which (while he was thus labouring to expound them) Galileo was already acting? From all that I can hear, it seems evident that the Inductive Philosophy received its great impulse, not from the great prophet of new principles, but from the great discoverers of new facts; not from Bacon, but from Galileo and Kepler. And I suppose that, with regard to those very principles even, if you wanted illustrations of what is commonly called the Baconian method, you would find some of the very best among the works of Gilbert and Galileo. What was it then that Bacon did which entitles him to be called the Regenerator of Philosophy? or what was it that he dreamt he was doing which made him think the work so entirely his own, so immeasurably important, and likely to be received with such incredulity by at least one generation of mankind?

B.

A pertinent question ; for there is no doubt that he was under that impression. "*Cum argumentum hujusmodi præ manibus habeam* (says he) *quod tractandi imperitiâ perdere et veluti exponere* NEFAS *sit.*" He was persuaded that the argument he had in charge was of such value that to risk the loss of it by unskilful handling would be not only a pity but an impiety. You wish to know, and the wish is reasonable, what it was. For answer I would refer you to the philosophers ; only I cannot say that their answers are satisfactory to myself. The old answer was that Bacon was the first to break down the dominion of Aristotle. This is now, I think, generally given up. His opposition to Aristotle was indeed conceived in early youth, and (though he was not the first to give utterance to it) I dare say it was not the less his own, and in the proper sense of the word, original. But the real overthrower of Aristotle was the great stir throughout the intellectual world which followed the Reformation and the revival of learning. It is certain that his authority had been openly defied some years before the publication of Bacon's principal writings ; and it could not in the nature of things have survived much longer. Sir John Herschel however, while he freely admits that the Aristotelian philosophy had been effectually overturned without Bacon's aid, still maintains Bacon's title to be looked upon in all future ages as the great Reformer of Philosophy ; not indeed that he *introduced* inductive reasoning as a new and untried process, but on account of his " keen perception and his broad and spirit-stirring, almost enthusiastic announcement of its paramount importance, as the alpha and omega of science, as the grand and only chain for linking together of physical truths, and the eventual key to every discovery and every application ".

A.

That is all very fine ; but it seems to me rather to account for his having the title than to justify his claim to it ;—rather to explain how he comes by his reputation than to prove that he deserves it. Try the question upon a modern case. We are now standing upon the threshold of a new era in the science of History. It is easy to see that the universal study of History must be begun afresh upon a new method. Tales, traditions, and all that has hitherto been accounted most authentic in our knowledge of past times, must be set aside as doubtful ; and the whole story must be spelt out anew from charters, names, inscriptions, monuments, and such like contemporary records. Now an eloquent man might easily make a broad and spirit-stirring announcement of the paramount importance of this process, as the only key by which the past can be laid open to us as it really was,—the grand and only chain for linking historical truths, and so forth. But would he thereby entitle himself to be called the great reformer of History ? Surely not. Such a man might perhaps get the credit, but it is Niebuhr that has done the thing : for Niebuhr was the first both to see the truth and to set the example.

B.

So, I confess, it seems to me. And if I thought that Bacon had aimed at no more than that, I should not think that his time had been altogether well-employed, or his sense of the importance of his own mission to mankind altogether justified. For surely a single great discovery made by means of the inductive process would have done more to persuade mankind of the paramount importance of it, than the most eloquent and philosophical exposition. Therefore in forsaking his experiments about gravitation, light, heat, etc., in order to set forth his classification of the " Prerogatives of Instances ", and to lay down general principles of philosophy, he would have been leaving the effectual promotion of his work to secure the exaltation of his name, than which nothing could be more opposite both to his principles and his practice. If his ambition had been only to have his picture stand as the frontispiece of the new philosophy, he could not have done better indeed than come forward as the most eloquent expounder of its principles. But if he wanted (as undoubtedly he did above all other things) to set it on work and bring it into fashion, his business was to pro-

duce the most striking illustration of its powers,—the most striking practical proof of what it could do.

Therefore if I thought, as Herschel seems to think, that there was no essential or considerable difference between the doctrines which Bacon preached and those which Galileo practised;—that Galileo was as the Niebuhr of the new philosophy (according to your own illustration) and Bacon only as your supposed eloquent man;—I should agree with you that Bacon's right to be called the Reformer of Philosophy is not made out. But when I come to look at Bacon's own exposition of his views and compare them with the latest and most approved account I have met with of Galileo's works, I cannot but think that the difference between what Galileo was doing and what Bacon wanted to be done is not only essential but immense.

A.

Nay, if the difference be immense, how comes it to be overlooked? It is from no want of the wish to claim for Bacon all the credit he deserves in that line.

B.

No. Rather perhaps from the wish to claim too much. We are so anxious to give him his due that we must needs ascribe to him all that has been done since his time; from which it seems to follow that we are practising his precepts, and that the Baconian philosophy has in fact been flourishing among us for the last 200 years. You believe this, don't you?

A.

People tell me so; and I suppose the only doubt is whether it be exclusively and originally his;—there is no doubt, I fancy, that it *is* his.

B.

Certainly that appears to be the general opinion; and it may seem an audacious thing in me to say that it is a mistake. But I cannot help it. It is true that a new philosophy is flourishing among us which was born about Bacon's time; and Bacon's name (as the brightest which presided at the time of its birth) has been inscribed upon it.

"Hesperus, that led
The starry host, rode brightest:"

not that Hesperus did actually *lead* the other stars; he and they were moving under a common force, and they would have moved just as fast if he had been away; but because he shone brightest, he *looked* as if he led them. But if I may trust Herschel, I must think that it is the *Galilean* philosophy that has been flourishing all these years; and if I may trust my own eyes and power of construing Latin, I must think that the *Baconian* philosophy has yet to come.

If Bacon were to reappear among us at the next meeting of the Great British Association,—or say rather if he had appeared there two or three years ago (for there seems to be something great and new going on now), I think he would have shaken his head. I think he would have said, "Here has been a great deal of very good diligence used by several persons; but it has not been used upon a well-laid plan. These solar systems, and steam-engines, and Daguerreotypes, and electric telegraphs, are so many more pledges of what might be expected from an instauration of philosophy such as I recommended more than 200 years ago; why have you not tried that? You have been acting all the time like a king who should attempt to conquer a country by encouraging private adventurers to make incursions each on his own account, without any system of combined movements to subdue and take possession. I see that wherever you have the proper materials and plenty of them your work is excellent; so was Gilbert's in my time; so was Galileo's; nay even Kepler—though his method was as unskilful as that of the boy who in doing a long-division sum would first guess at the quotient and then multiply it into the divisor to see whether it were true, and if it came out wrong would make another guess and multiply again, and so on till

he guessed right at last,—yet because he had a copious collection of materials ready to his hand, and enormous perseverance however perversely applied, and a religious veracity, did at last hit upon one of the greatest discoveries ever made by one man. But what could Kepler have done without Tycho Brahe's tables of observation? And what might Galileo not have done if he had had a large enough collection of facts? This therefore it is that disappoints me. I do not see any sufficient collection made of materials,—that is, of facts in nature—or any effectual plan on foot for making one. You are scarcely better off in that respect than I was; you have each to gather the materials upon which you are to work. You cannot build houses, or weave shirts, or learn languages so. If the builder had to make his own bricks, the weaver to grow his own flax, the student of a dead language to make his own concordance, where would be your houses, your shirts, or your scholars? And by the same rule if the interpreter of Nature is to forage for his facts, what progress can you expect in the art of interpretation? Your scholar has his dictionary provided to his hand; but your natural philosopher has still to make his dictionary for himself.

"And I wonder the more at this, because this is the very thing of all others which I myself pointed out as absolutely necessary to be supplied,—as the thing which was to be set about in the first place,—the thing *without* which no great things could possibly be done in philosophy. And since you have done me the honour to think so very highly of my precepts, I am a little surprised that you have not thought it worth while in so very essential a point to follow them. And to say the truth, I could wish for my own reputation (if that were of any consequence) that you had either honoured me a little more in that way, or not honoured me quite so much in other ways. You call me the Father of your Philosophy, meaning it for the greatest compliment you can pay. I thank you for the compliment, but I must decline the implied responsibility. I assure you this is none of mine.—May I ask whether any attempt has been made to collect that '*Historiam naturalem et experimentalem quæ sit in ordine ad condendam philosophiam*', concerning which I did certainly give some very particular directions;—which I placed as conspicuously as I could in the very front and entrance of my design;—of which I said that all the genius and meditation and argumentation in the world could not do instead of it; no, not if all men's wits could meet in one man's head; therefore that this we must have, or else the business must be given up?[2]—If this has been fairly tried and found impracticable or ineffectual, blot me out of your books as a dreamer that thought he had found out a great thing but it turned out nothing. If not, I still think it would be worth your while to try it."

A.

I partly comprehend your meaning; but I should prefer it in a less dramatic form. You think that the difference between what Galileo did and what Bacon wanted to be done, lay in this—that Bacon's plan presupposed a history (or dictionary as you call it) of Universal Nature, as a storehouse of facts to work upon; whereas Galileo was content to work upon such facts and observations as he collected for himself. But surely this is only a difference in degree. Both used the facts in the same way; only Bacon wanted a larger collection of them.

B.

Say rather, Bacon wanted a collection large *enough* to give him the command of all the avenues to the secrets of Nature. You might as well say that there is only a difference of degree between the method of the man who runs his single head against a fortress, and the man who raises a force strong enough to storm it,—because each uses the force he has in the same way, only one wants more of it than the other:—or between stopping *all* the leaks in a vessel and stopping as

[2] Neque huic labori et inquisitioni et mundanæ perambulationi, ulla ingenii aut meditationis aut argumentationis substitutio aut compensatio sufficere potest, non si omnia omnium ingenia coierint. Itaque aut hoc prorsus habendum aut negotium in perpetuum desetendum.

many as you conveniently can. The truth is, that though the difference between a *few* and *a few more* is only a difference of degree, the difference between *enough* and *not enough* is a difference in kind. According to Galileo's method, the work at best could be done but partially. According to Bacon's (so at least he believed) it would be done effectually and altogether.

I will put you a case by way of illustration. Two men (call them James and John) find a manuscript in a character unknown to either of them. James, being skilled in languages and expert at making out riddles, observes some characters similar to those of one of the languages which he understands; immediately sets himself to guess what they are; and succeeds in puzzling out here a name and there a date, with plausibility. Each succeeding guess, if it be right, makes the next easier; and there is no knowing precisely how much may be made out in this manner, or with what degree of certainty. The process is inductive, and the results, so far as they go, are discoveries. John seeing him thus employed comes up and says: "This is all very ingenious and clever, and far more than I could do by the same process. But you are not going the right way to work. You will never be able to decipher the manuscript in this way. I will tell you what we must do. Here (you see) are certain forms of character which continually recur. Here is one that comes more than once in every line; here another that comes once in every two or three lines; a third that comes only twice or thrice in a page; and so on. Let us have a list made of these several forms, with an index showing where and how often they occur. In the meantime I will undertake, upon a consideration of the general laws of language, to tell you, by the comparative frequency of their recurrence, what parts of speech most of these are. So we shall know which of them are articles, which conjunctions, which relatives, which auxiliaries, and so on. Setting these apart we shall be better able to deal with the nouns and verbs; and then by comparing the passages in which each occurs we shall be able, with the help of your language learning, to make out the meaning first of one, then of another. As each is determined, the rest will be easier to determine; and by degrees we shall come to know them all. It is a slow process compared with yours, and will take time and labour and many hands. But when it is done we shall be able to read the whole book."

Here I think you have a picture in little of the difference between Bacon's project for the advancement of philosophy and that which was carried into effect (certainly with remarkable success) by the new school of inductive science which flourished in his time. If we want to pursue the parallel further, we have only to suppose that John, after completing in a masterly manner a great portion of his work on the universal laws of language; after giving particular directions for the collection, arrangement, and classification of the index, and even doing several pages of it himself by way of example; is called away, and obliged to leave the completion of the work to his successors; and that his successors (wanting diligence to finish, patience to wait, or ability to execute) immediately fall back to the former method;—in which they make such progress and take such pride, that they never think of following out John's plan, but leave it exactly where he left it. And here I think you have a true picture of the state in which the matter now rests.

A.

I see. The manuscript is the volume of Nature. The learned linguist and expert maker-out of puzzles is Galileo or one of his school. The work on the laws of language is the *Novum Organum*. The index is the Natural and experimental History *quæ sit in ordine ad condendam Philosophiam*. The making-out of the words one by one is the Interpretation of Nature—

B.

And the ultimate reading of the whole book is the "*Historia Illuminata sive Veritas Rerum*"; the "*Philosophia Secunda*"; the sixth and last part of the Instauration; the consummation which Bacon knew he was not to be permitted himself to see, but trusted that (if men were true to themselves) the Fortune of the Human Race would one day achieve.

A.

And you think that they have not been true to themselves ?

B.

Why, what have they done with this work since he left it ? There it lies to speak for itself, sticking in the middle of the *Novum Organum*. No attempt has been made, that I can hear of, to carry it out further. People seem hardly to know that it is not complete. John Mill observes that Bacon's method of inductive logic is defective, but does not advert to the fact that of *ten* separate processes which it was designed to include, the first only has been explained. The other nine he had in his head, but did not live to set down more of them than the names. And the particular example which he has left of an inductive inquiry does not profess to be carried beyond the first stage of generalization,—the *vindemiatio prima* as he calls it.

A.

It may be so ; but *why* have they not attempted to carry his process out further ? Is it not because they have found that they can get on faster with their old tools ?

B.

Because they *think* they can get on faster ; you cannot say they have *found* it until they have tried.

A.

Have they not tried Bacon's way partially, and found it not so handy ? Has not Sir John Herschel, for instance, tried the use of his famous classification of Instances, and pronounced it " more apparent than real " ? And is it not a fact that no single discovery of importance has been actually made by proceeding according to the method recommended by Bacon ? I am sure I have heard as much reported upon the authority of a very eminent modern writer upon these subjects.

B.

So have I. And I can well believe that the use of Bacon's " Prerogatives of Instances ", *in the way they have been used*, is not much ; and for the reason given by Herschel, viz., because the same judgment which enables you to assign the Instance its proper *class*, enables you, without that assignation, to recognise its proper value. Therefore so long as the task of gathering his Instances as they grow wild in the woods is left to the Interpreter of Nature himself, there is little use in a formal classification ; he knows exactly what he wants ; what is not to his purpose he need not trouble himself with ; what is to his purpose he can apply to that purpose at once. And each several man of genius will no doubt acquire a knack of his own by which he will arrive at his results faster than by any formal method. But suppose the Interpreter wants to use the help of other people, to whom he cannot impart his own genius or his peculiar gift of knowing at first sight what is to the purpose and what not. He wants them to assist him in gathering materials. How shall he direct them in their task so that their labours may be available for himself ? I take it he must distribute the work among several and make it pass through several processes. One man may be used to make a rough and general collection,—what we call an *omnium gatherum*. Another must be employed to reduce the confused mass into some order fit for reference. A third to clear it of superfluities and rubbish. A fourth must be taught to classify and arrange what remains. And here I cannot but think that Bacon's arrangement of Instances according to what he calls their Prerogatives, or some better arrangement of the same kind which experience ought to suggest, would be found to be of great value ; especially when it is proposed to make through all the regions of Nature separate collections of this kind such as may combine into one general collection. For though it be true that as long as each man works only for himself he may trust to the *usus uni rei deditus* for finding out the method of proceeding which best suits the trick of his own mind,—and each will probably pursue a different method,—yet when many men's labours are to be gathered into one table,

any collector of statistics will tell you that they must all work according to a common pattern. And in the subject we are speaking of, which is coextensive with the mind of man on one side and the nature of things on the other, that will undoubtedly be the best pattern which is framed upon the justest theory of the human understanding;—for which distinction Bacon's would seem to be no unlikely candidate.

However I am here again getting out of my province. It may be that Bacon's project was visionary; or it may be that it is only *thought* visionary, because since his death no heart has been created large enough to believe it practicable. The philosophers must settle that among themselves. But be the cause what it will, it is clear to me on the one hand that the thing has not been seriously attempted; and on the other, that Bacon was fully satisfied that nothing of worth could be hoped for without it; therefore that we have no right to impute to him either the credit of all that has been done by the new philosophy, or the discredit of all that has been left undone.

A.

Certainly not; if you are right as to the fact. But I still think there must be some mistake. How is it possible that among so many distinguished men as have studied Bacon's philosophy with so much reverence, such a large feature can have been overlooked?

B.

I cannot pretend to explain that. But an appeal to one's own eyes is always lawful. Here is one passage which is enough by itself to settle the question. If you are not satisfied with it, I can quote half a dozen more to the same effect; "*Illud interim quod sæpe diximus etiam hoc loco præcipue repetendum est—*"

A.

Translate; if you would have me follow.

B.

"I must repeat here again what I have so often said;—that though all the wits of all the ages should meet in one,—though the whole human race should make Philosophy their sole business,—though the whole earth were nothing but colleges and academies and schools of learned men,—yet without such a natural and experimental history as I am going to describe, no progress worthy of the human race in Philosophy and the Sciences could possibly be made: whereas if such a history were once provided and well ordered with the addition of such auxiliary and light-giving experiments as the course of Interpretation would itself suggest, the investigation of Nature and of all sciences would be the work only of a few years. Either this must be done, therefore, or the business must be abandoned. For in this way and in this way only can the foundation be laid of all true and active Philosophy."

A.

Where does he say that?

B.

In the Preface to what he calls the "*Parasceve ad Historiam naturalem et experimentalem*", which is in fact nothing more than a description of the sort of history which he wanted,—such a history as a true Philosophy might be built upon,—with directions to be observed in collecting it. He published it (somewhat out of its proper place) in the same volume with the *Novum Organum*, in order that, if possible, men might be set about the work at once; of such primary importance did he hold it to be. If you distrust my translation, take it in his own English. In presenting the *Novum Organum* to the King, after explaining the nature and objects of the work and his reason for publishing it in an imperfect shape, he adds, "There is another reason for my so doing; which is to try whether I can get help in one intended part of this work, namely the compiling of a natural and experimental history, *which must be the main foundation of a true and active philosophy*". And again about a week after, in reply to the King's gracious acknowledgement of the book,—"This comfortable beginning makes me hope further that your

Majesty will be aiding to me in setting men on work for the collecting of a natural and experimental history, which is *basis totius negotii*". And this was no afterthought, but an essential feature of his design as he had conceived it at least sixteen years before. There is extant a description of this proposed history, which appears to have been written as early as 1604; and though the only copy that I know of is in an imperfect and mutilated manuscript, enough remains to show that in all its material features it agreed exactly with the description set forth in the *Parasceve*.

Now you know I am not going to discuss the merit of his plan. It may (as I said) have been all a delusion. But grant it a delusion—still it was a delusion under which he was actually labouring. If every man of science that ever lived had considered it and pronounced it puerile and ridiculous, still their unanimous verdict could not, in the face of his own repeated and earnest declarations, persuade me that it was not an essential part of Bacon's scheme; that it was not (in his perfect and rooted judgment) the one key to the cipher in which the fortunes of the human race are locked up,—the one thing *with* which all might be done; *without* which nothing. And this is all that is necessary for our present business. For we are not discussing his philosophical capacity, but his personal character and purposes as illustrated by the tenour of his life.

Such in 1847 were my reasons for rejecting as unsatisfactory all the explanations I had then met with of the distinctive peculiarity of the Baconian philosophy, and such the result of my attempts to find a more satisfactory one for myself.

In rejecting former explanations as unsatisfactory, Mr. Ellis, it will be seen, concurs with me, and for much the same reason. According to them "it becomes", he says, "impossible to justify or to understand Bacon's assertion that his system was essentially new". He then proceeds to point out one great peculiarity by which it aspired to differ from all former systems—a peculiarity residing in the supposed perfection of the logical machinery; which, since it would of itself account for Bacon's belief of its importance no less than for his assertion of its novelty, does certainly supply a new explanation unencumbered with the difficulties pointed out in the foregoing extract. But there is another difficulty which it leaves behind. It is impossible, I think, to reconcile with this supposition the course which Bacon afterwards took in expounding and developing his system. For if the great secret which he had, or thought he had, in his keeping, lay only, or even chiefly, in the perfection of the logical machinery—in the *method* of induction; if this method was a kind of mechanical process—an *organum* or engine—at once "wholly new", "universally applicable," "in all cases infallible," and such as anybody might manage; if his explanation of this method in the second book of the *Novum Organum* is so incomplete that it leaves all the principal practical difficulties unexplained; and if it was a thing which nobody but himself had any notion of, or any belief in; how is it that, during the remaining five years of his life—years of eager and unremitting labour, devoted almost exclusively to the exposition of his philosophy—he made no attempt to complete the explanation of it? Why did he leave the *Novum Organum* as it was, being a work which he could have completed alone, and which indeed he only could have completed, and apply himself with advised and deliberate industry to the collection of Natural History; a work which he knew he could not carry to perfection himself, even in any of its parts; which he had once thought it a waste of time to employ himself upon, as being within every man's capacity; concerning the execution of which he had already given sufficient general directions; and of which, even when accomplished, the right use could not be made except in virtue of that very *method* or logical machinery, the constitution and management of which still remained to be explained? It was not that he had changed his opinion as to the value of it; his sense of the difficulties may have increased, his views as to details may have altered; but there is no reason to think that he ever lost any part of his faith either in the importance or in the practicability of it. It was not that when he came to closer quarters with the subject, he felt that he was himself unable to deal with it: Two years after the publication of the first part of the *Novum Organum*, and three years before his death, he speaks of the second part as a thing

yet to be done, but adds, " quam tamen animo jam complexus et metitus sum " [3]. It was not that he thought the description he had already given sufficient. In the winter of 1622, he tells us that there are " haud pauca, *eaque ex præcipuis*," still wanting. It was not that he had found any disciple or fellow-labourer to whom he might entrust the completion of his unfinished task: to the very last he felt himself alone in his work. It was not from inadvertence: he left the *Novum Organum* for the *Natural History* deliberately, because it seemed upon consideration the better and more advisable course; " quare omnino et ante omnia in hoc incumbere *satius et consultius* visum est ". It was not that he wanted either time or industry; for during the five succeeding years he completed the *De Augmentis*, and composed his histories of the *Winds*, of *Life and Death*, of *Dense and Rare*; his lost treatise on *Heavy and Light*, his lost *Abecedarium Naturæ*, his *New Atlantis*, his *Sylva Sylvarum*. Why did he employ no part of that time in completing the description of the new machine? in explaining how he proposed to supply the defects [4] and rectify the errors [5] of the imperfect logical process which he had already exhibited; how to adapt the mode of inquiry to the nature of the subject [6]; how to determine what questions ought to be dealt with first,—what " natures " to have precedence in the order of inquiry [7]; above all, how to ascertain where the inquiry might safely terminate as having left no " nature " in the universe unchallenged [8],—a security without which the whole process must always have been in danger of vitiation from an " instance contradictory " remaining behind? To me the question appears to admit of but one answer. He considered the collection of natural history upon the plan he meditated, to be, in practice at least, a more important part of his philosophy than the *Organum* itself,—a work of which the nature and importance more needed to be pressed upon the attention of mankind,—of which the neglect would be more fatal to the progress of science. That this was in fact his opinion at the very time he was composing the *Novum Organum* may be inferred from the last aphorism of the first book, as I have pointed out at the end of the preface. That he was still of the same opinion two years after, we have his own express declaration in the *Auctoris monitum* prefixed to the *History of the Winds*, where he explains his motives for going on with the third part of the Instauratio, instead of finishing the second. It had occurred to him, he there tells us, that if the *Organum* should fall into the hands of some man of genius capable of understanding and willing to use it, still without a natural history of the proper kind provided to his hand, he would not know how to proceed; whereas if a full and faithful history of nature and the arts were set before him, he might succeed *even by the old method*—" licet via veteri pergere malint, nec via nostri organi (quæ ut nobis videtur aut unica est aut optima) uti "—in building upon it something of solid worth. " Itaque huc res redit " he concludes; " ut *organum nostrum*, etiamsi fuerit absolutum, *absque historiâ naturali non multum, historia naturalis absque organo non parum*, instaurationem scientiarum sit provectura." I know not how therefore to escape the conclusion that, in Bacon's own estimate of his own system, the Natural History held the place of *first* importance. He regarded it as not less new [9] than the new *method*, and as more indispensable. Though the " *via nostri organi* " still appeared to him to be " *aut unica aut optima* ", something of substantial worth might, he thought, be accomplished without it. Without a natural history " tali qualem nunc præcipiemus ", he thought no advance of any value could possibly be made.

[3] Letter to Fulgenzio.

[4] De Adminiculis Inductionis.

[5] De Rectificatione Inductionis.

[6] De Variatione Inquisitionis pro naturâ subjecti.

[7] De Prærogativis Naturarum quatenus ad inquisitionem, sive de eo quod inquirendum est prius et posterius.

[8] De Terminis Inquisitionis, sive de Synopsi omnium naturarum in universo.

[9] His assertion of the *novelty* is as strong in the one case as in the other. *Atque hoc posterius* [viz. the use of natural history, " tanquam materia prima philosophiæ atque veræ inductionis supellex sive sylva "] *nunc agitur; nunc inquam*, NEQUE UNQUAM ANTEHAC."

What may be the real value of this part of Bacon's system is, of course, quite another question. The evidence just adduced goes only to show what was the value which he himself set upon it, and affects the question no otherwise than by giving it a new interest, and suggesting the expediency of considering more carefully than has yet, I think, been done, whether his advice on this head might not be followed—I do not say as far as he intended—but much further than has yet been tried; with effects—I do not say such as he anticipated—but larger than we are likely to get any other way.

That he himself indeed, even if all mankind had united to carry his plan into effect, would have been disappointed with the result, I have little doubt. For I suppose the collected observations of all the world,—reduced to writing, digested, and brought into his study,—would not have sufficed to give him that knowledge of the *forms* of nature which was to carry with it the command over her powers. He would have found no doubt, upon trial, that his scheme involved difficulties of which he had formed no conception. He would have found that the facts which must be known in order to complete the three tables of comparence, and to "perfect the *exclusiva*", were so infinite in number that to gather them by simple observation without some theoretic principle of selection would be an endless task, and to deal with them when gathered a hopeless one. He might still indeed have hoped to arrive ultimately at an *alphabet* of nature (her principles being probably few and simple, though her phenomena so enormously complex); but he would have found that a *dictionary* or *index* of nature (and such was to be the office of the *Natural History*), to be complete enough for the purposes of the *Novum Organum*, must be nearly as voluminous as Nature herself. He would have found it necessary, therefore (as I suppose all inventors have done both before and since his time), to make material changes in his original plan of operation, and to reduce his hopes far below their original dimensions. But a man may be in the right way to his end, though the end itself be further off than he imagines; and before we cast Bacon's plan finally aside, we may be fairly called upon to show either that the way he wanted us to go is in its nature impracticable or that there is better hope of arriving at the desired end by some other.

Mr. Ellis's judgment upon the first point may be partly gathered from his general remarks upon the third part of the Instauratio; but I am fortunately in possession of his opinion (called forth by the exposition of my own views in the dialogue above quoted) upon the specific practical question now under discussion. It was communicated to me in a letter dated 13th September, 1847, and appears to contain his deliberate judgment as to the *practicability* of making a collection of natural history, such as would be available for scientific purposes, in the manner in which Bacon proposed to have it made.

"That it is impossible (he says) to sever the business of experiment and observation from that of theorising, it would perhaps be rash to affirm. But it seems to me that such a severance could hardly be effected. A transcript of nature, if I may so express myself,—that is, such a collection of observed phenomena as would serve as the basis and materials of a system of natural philosophy,—would be like nature itself infinite in extent and variety. No such collection could be formed; and, were it formed, general laws and principles would be as much hidden in a mass of details as they are in the world of phenomena.

"The marshalling idea, teaching the philosopher what observations he is to make, what experiments to try, seems necessary in order to deliver him from this difficulty. Can we conceive that such experiments as those of Faraday could have preceded the formation of any hypothesis? You allude, I think, to what has been done in the way of systematic observation with reference to terrestrial magnetism. And beyond all doubt the division of labour is possible and necessary in many scientific inquiries. But then this separating of the observer from the theoriser is only possible (at least, in such a case as that of magnetism) when the latter can tell his "bajulus" what experiments he is to make, and how they are to be made. As a matter of fact, the memoirs of Gauss, which have done so much to encourage systematic observation of terrestrial magnetism, contain many results of theory directly bearing on observation; *e.g.*, the method of determining the absolute measure of magnetism.

* * * * *

"Of course I remember that Bacon speaks of experiments to be suggested by theory: as for instance in Solomon's house; all I mean is, that it seems doubtful whether a large collection of facts can in most sciences be made useful, unless some theory has guided its formation."

Now I am quite willing to accept this judgment as perfectly sound and just; as pointing truly at the practical difficulties involved in Bacon's scheme, and proving that it could not be carried out *completely* on the plan he proposed, or attain *completely* the end at which he aimed; and certainly, if I thought that such completeness was a condition absolutely essential,—that, unless observation could be carried on without any help whatever from theory, the work could not proceed at all; or that the results of observation so conducted could be of no scientific value unless they amounted to a perfect "transcript of nature;"—if I thought, in short, it was a scheme which, unless it led to everything, would lead to nothing,—I should accept these remarks as disposing finally of the whole question. But why should I think so? That the severance of theory and observation should be *absolute* does not appeal to me to be at all necessary for the practical prosecution of the enterprise; I can hardly think that it even formed part of the original design; and though it is true that the collection of natural history could not have been used *in the way Bacon proposed*, unless it were more complete than it ever could have been made, yet for use in the ordinary way (and this was certainly *one* of the uses he contemplated for it) its value would be increased by every new observation; and who can say at what point observations so conducted must necessarily stop?

That Bacon intended one set of men to be employed in collecting facts, and another in deriving consequences from them, is no doubt true. Unless theory and observation could be so far separated as to admit practically of such a distribution of parts, his plan must no doubt have been given up, and it is objected that his distribution is practically impossible, because the observers, unless they had some precedent theory to guide them, could never know what observations to make in order to bring out the facts which the theorist requires to know. I cannot but think, however, that this objection supposes a separation of the two functions far more complete than Bacon ever contemplated. He may have used words which in strict logical construction imply such a kind of separation; but if so, his words meant more than he himself meant. His intellect was remarkable for breadth rather than subtlety,—quicker, to use his own division, in perceiving resemblances than distinctions,—and in writing he always aimed at conciseness, force, point, picturesqueness, and at making himself plain to common understandings, far more than at metaphysical exactness of expression. Now, however true it may be, as a metaphysical proposition, that some amount of theory is involved in every observation, and still more in every series of observations, it is no less true, as a familiar fact, that observations made by one man, without conscious reference to any theory whatever, may be perfectly available to another with reference to theories of which the first never heard or dreamed. Colonel Reid's theory of storms, for instance, was worked out, I am told, not in the West Indies among the hurricanes, but at the Admiralty among the ship's logs. And though Bacon would never have denied that many results of theory go to the correct keeping of a ship's log, who can doubt that a collection of logs kept during hurricanes would have been accepted by him as a most valuable contribution to a history of the winds, and a good specimen of the very thing he wanted? It would be easy to add more instances; but I suppose nobody will deny that, *in this sense*, observation and theory *can* be carried on apart and by different persons. And if it be objected that the observers will never hit upon all the facts which are necessary to suggest or establish the theory, unless their observations be renewed again and again under directions devised by the theorist with special reference to what he wants to know, I reply by asking what is to prevent the renewal of them, under directions so devised, as often as necessary? a thing (I may observe) which Bacon himself distinctly intended. "Illud interim," he says, after giving an example of a "topica particularis" in the *De Augmentis*, "quod monere occœpimus iterum monemus, nempe ut homines debeant topicas particulares suas alternare, ita ut post majores progressus aliquos in inquisitione factos, *aliam et subinde aliam in-*

stituant topicam, si modo scientiarum fastigia conscendere cupiant." Now if the directions, judicious to begin with, be judiciously varied and repeated as the inquiry proceeds, an immense mass of observations of the greatest importance to science might surely be collected in this very way. Nay, in subjects which have their phenomena spread far and wide over the world (like winds, seasons, and oceanic or atmospheric currents), it is in the gradual accumulation of observations so made that our only hope lies of ever coming to understand their laws at all; and if we cannot cause them to be collected under direction and design, we must wait till they accumulate by accident. For it is manifestly impossible that in such subjects as these, philosophers should provide themselves with all the facts which they want unless they can use the help of those who are not philosophers. What science deals with phenomena more subtle and delicate than meteorology? Yet hear Sir John Herschel. "It happens fortunately that almost every *datum* which the scientific meteorologist can require is furnished in its best and most available state by that definite systematic process known as the '*keeping a meteorological register*', which consists in noting at stated hours of every day the readings of all the meteorological instruments at command, as well as all such facts or indications of wind and weather as are susceptible of being definitely described and estimated without instrumental aid. Occasional observations apply to occasional and remarkable phenomena, and are by no means to be neglected; *but it is to the regular meteorological register, steadily and perseveringly kept throughout the whole of every voyage, that we must look for the development of the great laws of this science* [10]."

Between the officers of Her Majesty's navy registering the readings of their instruments in all latitudes and longitudes, and the man of science in his study deducing the laws of meteorology from a comparison of the results, the division of labour is surely as complete as Bacon would have desired. Nor would the scientific directions previously furnished to the officers for their guidance, directions when, where, what, and how to observe and record,—though containing "many results of theory bearing upon observation,"—have seemed to him either objectionable or superfluous: on the contrary, such directions form part of his own design as explained by himself. In the concluding paragraph of the tract which has suggested these remarks he distinctly announces his intention to draw up certain heads of inquiry showing what points with reference to each subject were more particularly to be observed. And though he did not live to execute this part of his design, a few fragments remaining among his papers show in what manner he proposed to proceed. And (if an idle looker-on who can offer no help in the work may presume to offer an opinion) I could wish that men of science would apply themselves earnestly to the solution of this practical problem: What measures are to be taken in order that the greatest variety of judicious observations of nature all over the world may be carried on in concert upon a scientific plan, and brought to a common centre? With reference to some particular subjects, such measures have been of late years taken on a scale of Baconian magnitude. The system of observations instituted by the Great British Association with respect to Terrestrial Magnetism, if I am rightly informed as to the nature and scale of it, is one which Bacon would have welcomed as he welcomed the first tidings from Galileo's telescope; he would have accepted it as an enterprise "dignum humano genere". A similar system of concerted observations is now in contemplation with regard to oceanic currents. As a specimen of the same thing in a more general character, take the "Admiralty Manual of Scientific Inquiry", to which I have already referred; a book of practical directions drawn up by some of the most eminent scientific men of our day with special reference to the progress of science in several of its most important departments; directions addressed not to men who are themselves engaged in the theoretical investigation of the subjects, or guided by any "marshalling idea", but to "officers of the navy and travellers in general", telling them what things to observe, in order that their observations may be available for the pur-

[10] "Manual of Scientific Inquiry, prepared for the use of officers in Her Majesty's navy and travellers in general." Edited by Sir John F. W. Herschel, Bt., p. 281.

poses of scientific inquiry. These are exactly what Bacon would have called "Topicæ Inquisitionis"—instructions for the examination of Nature "super articulos"; and the whole scheme is in perfect accordance, so far as it goes, with Bacon's notion of the way in which men might be set on work for the completing of a natural and experimental history. Why should it not go further? Who can believe that the subjects contained in this little volume are the only subjects to which this method of collecting observations can be applied? who venture to fix the limit beyond which, under such a system sagaciously devised, wisely administered, energetically carried out, and extended to all the departments of nature which admit of it, human discovery may not go?—*J. S.*

DESCRIPTION OF A NATURAL AND EXPERIMENTAL HISTORY, SUCH AS MAY SERVE FOR THE FOUNDATION OF A TRUE PHILOSOPHY.

My object in publishing my Instauration by parts is that some portion of it may be put out of peril. A similar reason induces me to subjoin here another small portion of the work, and to publish it along with that which has just been set forth. This is the description and delineation of a Natural and Experimental History such as may serve to build philosophy upon, and containing material true and copious and aptly digested for the work of the Interpreter which follows. The proper place for it would be when I come in due course to the *Preparatives* of Inquiry. I have thought it better however to introduce it at once without waiting for that. For a history of this kind, such as I conceive and shall presently describe, is a thing of very great size, and cannot be executed without great labour and expense; requiring as it does many people to help, and being (as I have said elsewhere) a kind of royal work. It occurs to me therefore that it may not be amiss to try if there be any others who will take these matters in hand; so that while I go on with the completion of my original design, this part which is so manifold and laborious may even during my life (if it so please the Divine Majesty) be prepared and set forth, others applying themselves diligently to it along with me; the rather because my own strength (if I should have no one to help me) is hardly equal to such a province. For as much as relates to the work itself of the intellect, I shall perhaps be able to master that by myself; but the materials on which the intellect has to work are so widely spread, that one must employ factors and merchants to go everywhere in search of them and bring them in. Besides I hold it to be somewhat beneath the dignity of an undertaking like mine that I should spend my own time in a matter which is open to almost every man's industry. That however which is the main part of the matter I will myself now supply, by diligently and exactly setting forth the method and description of a history of this kind, such as shall satisfy my intention; lest men for want of warning set to work the wrong way, and guide themselves by the example of the natural histories now in use, and so go far astray from my design. Meanwhile what I have often said I must here emphatically repeat; that if all the wits of all the ages had met, or shall hereafter meet together; if the whole human race had applied or shall hereafter apply themselves to philosophy, and the whole earth had been or shall be nothing but academies and colleges and schools of learned men; still without a natural and experimental history such as I am going to prescribe, no progress worthy of the human race could have been made or can be made in philosophy and the sciences. Whereas on the other hand, let such a history be once provided and well set forth, and let there be added to it such auxiliary and light-giving experiments as in the very course of interpretation will present themselves or will have to be found out; and the investigation of nature and of all sciences will be the work of a few years. This therefore must be done, or the business must be given up. For in this way, and in this way only, can the foundations of a true and active philosophy be established; and then will men wake as from deep sleep, and at once perceive what a difference there is between the dogmas and figments of the wit and a true and active philosophy, and what it is in questions of nature to consult nature herself.

First then I will give general precepts for the composition of this history; then I will set out the particular figure of it, inserting sometimes as well the purpose to which the inquiry is to be adapted and referred as the particular point to be inquired; in order that a good understanding and forecast of the mark aimed at may suggest to men's minds other things also which I may perhaps have overlooked. This history I call *Primary History*, or the *Mother History*.

APHORISMS ON THE COMPOSITION OF THE PRIMARY HISTORY.

APHORISM

I.

NATURE exists in three states, and is subject as it were to three kinds of regimen. Either she is free, and develops herself in her own ordinary course; or she is forced out of her proper state by the perverseness and insubordination of matter and the violence of impediments; or she is constrained and moulded by art and human ministry. The first state refers to the *species* of things; the second to *monsters;* the third to *things artificial.* For in things artificial nature takes orders from man, and works under his authority: without man, such things would never have been made. But by the help and ministry of man a new face of bodies, another universe or theatre of things, comes into view. Natural History therefore is threefold. It treats of the *liberty* of nature, or the *errors* of nature, or the *bonds* of nature: so that we may fairly distribute it into history of *Generations*, of *Pretergenerations*, and of *Arts;* which last I also call *Mechanical* or *Experimental* history. And yet I do not make it a rule that these three should be kept apart and separately treated. For why should not the history of the monsters in the several species be joined with the history of the species themselves? And things artificial again may sometimes be rightly joined with the species, though sometimes they will be better kept separate. It will be best therefore to consider these things as the case arises. For too much method produces iterations and prolixity as well as none at all.

II.

Natural History, which in its subject (as I said) is threefold, is in its use twofold. For it is used either for the sake of the knowledge of the particular things which it contains, or as the primary material of philosophy and the stuff and subject-matter of true induction. And it is this latter which is now in hand: now, I say, for the first time: nor has it ever been taken in hand till now. For neither Aristotle, nor Theophrastus, nor Dioscorides, nor Caius Plinius, ever set this before them as the end of natural history. And the chief part of the matter rests in this: that they who shall hereafter take it upon them to write natural history should bear this continually in mind—that they ought not to consult the pleasure of the reader, no nor even that utility which may be derived immediately from their narrations; but to seek out and gather together such store and variety of things as may suffice for the formation of true axioms. Let them but remember this, and they will find out for themselves the method in which the history should be composed. For the end rules the method.

III.

But the more difficult and laborious the work is, the more ought it to be discharged of matters superfluous. And therefore there are three things upon which men should be warned to be sparing of their labour,—as those which will immensely increase the mass of the work, and add little or nothing to its worth.

First then, away with antiquities, and citations or testimonies of authors; also with disputes and controversies and differing opinions; everything in short which is philological. Never cite an author except in a matter of doubtful credit: never introduce a controversy unless in a matter of great moment. And for all that concerns ornaments of speech, similitudes, treasury of eloquence, and such like emptinesses, let it be utterly dismissed. Also let all those things which are admitted be themselves set down briefly and concisely, so that they may be nothing less than words. For no man who is collecting and storing up materials for ship-building or the like, thinks of arranging them elegantly, as in a shop, and

displaying them so as to please the eye ; all his care is that they be sound and good, and that they be so arranged as to take up as little room as possible in the warehouse. And this is exactly what should be done here.

Secondly, that superfluity of natural histories in descriptions and pictures of species, and the curious variety of the same, is not much to the purpose. For small varieties of this kind are only a kind of sports and wanton freaks of nature ; and come near to the nature of individuals. They afford a pleasant recreation in wandering among them and looking at them as objects in themselves ; but the information they yield to the sciences is slight and almost superfluous.

Thirdly, all superstitious stories (I do not say stories of prodigies, when the report appears to be faithful and probable ; but superstitious stories) and experiments of ceremonial magic should be altogether rejected. For I would not have the infancy of philosophy, to which natural history is as a nursing-mother, accustomed to old wives' fables. The time will perhaps come (after we have gone somewhat deeper into the investigation of nature) for a light review of things of this kind ; that if there remain any grains of natural virtue in these dregs, they may be extracted and laid up for use. In the meantime they should be set aside. Even the experiments of natural magic should be sifted diligently and severely before they are received ; especially those which are commonly derived from vulgar sympathies and antipathies, with great sloth and facility both of believing and inventing.

And it is no small thing to relieve natural history from the three superfluities above mentioned, which would otherwise fill volumes. Nor is this all. For in a great work it is no less necessary that what is admitted should be written succinctly than that what is superfluous should be rejected ; though no doubt this kind of chastity and brevity will give less pleasure both to the reader and the writer. But it is always to be remembered that this which we are now about is only a granary and storehouse of matters, not meant to be pleasant to stay or live in, but only to be entered as occasion requires, when anything is wanted for the work of the *Interpreter*, which follows.

IV.

In the history which I require and design, special care is to be taken that it be of wide range and made to the measure of the universe. For the world is not to be narrowed till it will go into the understanding (which has been done hitherto), but the understanding to be expanded and opened till it can take in the image of the world, as it is in fact. For that fashion of taking few things into account, and pronouncing with reference to a few things, has been the ruin of everything. To resume then the divisions of natural history which I made just now,—viz. that it is a history of Generations, Pretergenerations, and Arts,—I divide the History of Generations into five parts. The first, of Ether and things Celestial. The second, of Meteors and the regions (as they call them) of Air ; viz. of the tracts which lie between the moon and the surface of the earth ; to which part also (for order's sake, however the truth of the thing may be) I assign Comets of whatever kind, both higher and lower. The third, of Earth and Sea. The fourth, of the Elements (as they call them), flame or fire, air, water, earth ; understanding however by Elements, not the first principles of things, but the greater masses of natural bodies. For the nature of things is so distributed that the quantity or mass of some bodies in the universe is very great, because their configurations require a texture of matter easy and obvious ; such as are those four bodies which I have mentioned ; while of certain other bodies the quantity is small and weakly supplied, because the texture of matter which they require is very complex and subtle, and for the most part determinate and organic ; such as are the species of natural things,—metals, plants, animals. Hence I call the former kind of bodies the *Greater Colleges*, the latter the *Lesser Colleges*. Now the fourth part of the history is of those Greater Colleges—under the name of Elements, as I said. And let it not be thought that I confound this fourth part with the second and third, because in each of them I have mentioned air, water, and earth. For the history of these enters into the second and third, as they are integral parts of the world, and as they relate to the fabric and con-

figuration of the universe. But in the fourth is contained the history of their own substance and nature, as it exists in their several parts of uniform structure, and without reference to the whole. Lastly, the fifth part of the history contains the Lesser Colleges, or Species; upon which natural history has hitherto been principally employed.

As for the history of Pretergenerations, I have already said that it may be most conveniently joined with the history of Generations; I mean the history of prodigies which are natural. For the superstitious history of marvels (of whatever kind) I remit to a quite separate treatise of its own; which treatise I do not wish to be undertaken now at first, but a little after, when the investigation of nature has been carried deeper.

History of Arts, and of Nature as changed and altered by Man, or Experimental History, I divide into three. For it is drawn either from mechanical arts, or from the operative part of the liberal arts; or from a number of crafts and experiments which have not yet grown into an art properly so called, and which sometimes indeed turn up in the course of most ordinary experience, and do not stand at all in need of art.

As soon therefore as a history has been completed of all these things which I have mentioned, namely, Generations, Pretergenerations, Arts and Experiments, it seems that nothing will remain unprovided whereby the sense can be equipped for the information of the understanding. And then shall we be no longer kept dancing within little rings, like persons bewitched, but our range and circuit will be as wide as the compass of the world.

V.

Among the parts of history which I have mentioned, the history of Arts is of most use, because it exhibits things in motion, and leads more directly to practice. Moreover it takes off the mask and veil from natural objects, which are commonly concealed and obscured under the variety of shapes and external appearance. Finally, the vexations of art are certainly as the bonds and handcuffs of Proteus, which betray the ultimate struggles and efforts of matter. For bodies will not be destroyed or annihilated; rather than that they will turn themselves into various forms. Upon this history therefore, mechanical and illiberal as it may seem (all fineness and daintiness set aside), the greatest diligence must be bestowed.

Again, among the particular arts those are to be preferred which exhibit, alter, and prepare natural bodies and materials of things; such as agriculture, cookery, chemistry, dyeing; the manufacture of glass, enamel, sugar, gunpowder, artificial fires, paper, and the like. Those which consist principally in the subtle motion of the hands or instruments are of less use; such as weaving, carpentry, architecture, manufacture of mills, clocks, and the like; although these too are by no means to be neglected, both because many things occur in them which relate to the alterations of natural bodies, and because they give accurate information concerning local motion, which is a thing of great importance in very many respects.

But in the whole collection of this history of Arts, it is especially to be observed and constantly borne in mind, that not only those experiments in each art which serve the purpose of the art itself are to be received, but likewise those which turn up anyhow by the way. For example, that locusts or crabs, which were before of the colour of mud, turn red when baked, is nothing to the table; but this very instance is not a bad one for investigating the nature of redness, seeing that the same thing happens in baked bricks. In like manner the fact that meat is sooner salted in winter than in summer, is not only important for the cook that he may know how to regulate the pickling, but is likewise a good instance for showing the nature and impression of cold. Therefore it would be an utter mistake to suppose that my intention would be satisfied by a collection of experiments of arts made only with the view of thereby bringing the several arts to greater perfection. For though this be an object which in many cases I do not despise, yet my meaning plainly is that all mechanical experiments should be as streams flowing from all sides into the sea of philosophy. But how

to select the more important instances in every kind (which are principally and with the greatest diligence to be sought and as it were hunted out) is a point to be learned from the prerogatives of instances.

VI.

In this place also is to be resumed that which in the 99th, 119th, and 120th Aphorisms of the first book I treated more at large, but which it may be enough here to enjoin shortly by way of precept; namely, that there are to be received into this history, first, things the most ordinary, such as it might be thought superfluous to record in writing, because they are so familiarly known; secondly, things mean, illiberal, filthy (for "to the pure all things are pure," and if money obtained from Vespasian's tax smelt well, much more does light and information from whatever source derived); thirdly, things trifling and childish (and no wonder, for we are to become again as little children); and lastly, things which seem over subtle, because they are in themselves of no use. For the things which will be set forth in this history are not collected (as I have already said) on their own account; and therefore neither is their importance to be measured by what they are worth in themselves, but according to their indirect bearing upon other things, and the influence they may have upon philosophy.

VII.

Another precept is, that everything relating both to bodies and virtues in nature be set forth (as far as may be) numbered, weighed, measured, defined. For it is works we are in pursuit of, not speculations; and practical working comes of the due combination of physics and mathematics. And therefore the exact revolutions and distances of the planets—in the history of the heavenly bodies; the compass of the land and the superficial space it occupies in comparison of the waters—in the history of earth and sea; how much compression air will bear without strong resistance—in the history of air; how much one metal outweighs another—in the history of metals; and numberless other particulars of that kind are to be ascertained and set down. And when exact proportions cannot be obtained, then we must have recourse to indefinite estimates and comparatives. As for instanse (if we happen to distrust the calculations of astronomers as to the distances of the planets), that the moon is within the shadow of the earth; that Mercury is beyond the moon; and the like. Also when mean proportions cannot be had, let extremes be proposed; as that a weak magnet will raise so many times its own weight of iron, while the most powerful will raise sixty times its own weight (as I have myself seen in the case of a very small armed magnet). I know well enough that these definite instances do not occur readily or often, but that they must be sought for as auxiliaries in the course of interpretation itself when they are most wanted. But nevertheless if they present themselves accidentally, provided they do not too much interrupt the progress of the natural history, they should also be entered therein.

VIII.

With regard to the credit of the things which are to be admitted into the history; they must needs be either certainly true, doubtful whether true or not, or certainly not true. Things of the first kind should be set down simply; things of the second kind with a qualifying note, such as "it is reported", "they relate," "I have heard from a person of credit," and the like. For to add the arguments on either side would be too laborious and would certainly interrupt the writer too much. Nor is it of much consequence to the business in hand; because (as I have said in the 118th Aphorism of the first book) mistakes in experimenting, unless they abound everywhere, will be presently detected and corrected by the truth of axioms. And yet if the instance be of importance, either from its own use or because many other things may depend upon it, then certainly the name of the author should be given; and not the name merely, but it should be mentioned withal whether he took it from report, oral or written (as most of Pliny's statements are), or rather affirmed it of his own knowledge; also whether it was

a thing which happened in his own time or earlier ; and again whether it was a thing of which, if it really happened, there must needs have been many witnesses ; and finally whether the author was a vainspeaking and light person, or sober and severe ; and the like points, which bear upon the weight of the evidence. Lastly things which though certainly not true are yet current and much in men's mouths, having either through neglect or from the use of them in similitudes prevailed now for many ages, (as that the diamond binds the magnet, garlic weakens it ; that amber attracts everything except basil ; and other things of that kind) these it will not be enough to reject silently ; they must be in express words proscribed, that the sciences may be no more troubled with them.

Besides, it will not be amiss, when the source of any vanity or credulity happens to present itself, to make a note of it ; as for example, that the power of exciting Venus is ascribed to the herb *Satyrion*, because its root takes the shape of testicles ; when the real cause of this is that a fresh bulbous root grows upon it every year, last year's root still remaining ; whence those twin bulbs. And it is manifest that this is so ; because the new root is always found to be solid and succulent, the old withered and spongy. And therefore it is no marvel fi one sinks in water and the other swims ; which nevertheless goes for a wonder, and has added credit to the other virtues ascribed to this herb.

IX.

There are also some things which may be usefully added to the natural history, and which will make it fitter and more convenient for the work of the interpreter which follows. They are five.

First, questions (I do not mean as to causes but as to the fact) should be added, in order to provoke and stimulate further inquiry ; as in the history of Earth and Sea, whether the Caspian ebbs and flows, and at how many hours' interval ; whether there is any Southern Continent, or only islands ; and the like.

Secondly, in any new and more subtle experiment the manner in which the experiment was conducted should be added, that men may be free to judge for themselves whether the information obtained from that experiment be trustworthy or fallacious ; and also that men's industry may be roused to discover if possible methods more exact.

Thirdly, if in any statement there be anything doubtful or questionable, I would by no means have it suppressed or passed in silence, but plainly and perspicuously set down by way of note or admonition. For I want this primary history to be compiled with a most religious care, as if every particular were stated upon oath ; seeing that it is the book of God's works, and (so far as the majesty of heavenly may be compared with the humbleness of earthly things) a kind of second Scripture.

Fourthly, it would not be amiss to intersperse observations occasionally, as Pliny has done ; as in the history of Earth and Sea, that the figure of the earth (as far as it is yet known) compared with the seas, is narrow and pointed towards the south, wide and broad towards the north ; the figure of the sea contrary :— that the great oceans intersect the earth in channels running north and south, not east and west ; except perhaps in the extreme polar regions. It is also very good to add canons (which are nothing more than certain general and catholic observations) ; as in the history of the Heavenly Bodies, that Venus is never distant more than 46 parts from the sun ; Mercury never more than 23 ; and that the planets which are placed above the sun move slowest when they are furthest from the earth, those under the sun fastest. Moreover there is another kind of observation to be employed, which has not yet come into use, though it be of small importance. This is, that to the enumeration of things which are should be subjoined an enumeration of things which are not. As in the history of the Heavenly Bodies, that there is not found any star oblong or triangular, but that every star is globular ; either globular simply, as the moon ; or apparently angular but globular in the middle, as the other stars ; or apparently radiant but globular in the middle, as the sun ;—or that the stars are scattered about the sky in no order at all ; so that there is not found among them either quincunx or square, or any other regular figure (howsoever the names be given of Delta, Crown,

Cross, Chariot, etc.),—scarcely so much as a straight line ; except perhaps in the belt and dagger of Orion.

Fifthly, that may perhaps be of some assistance to an inquirer which is the ruin and destruction of a believer ; viz. a brief review, as in passage, of the opinions now received, with their varieties and sects ; that they may touch and rouse the intellect, and no more.

X.

And this will be enough in the way of general precepts ; which if they be diligently observed, the work of the history will at once go straight towards its object and be prevented from increasing beyond bounds. But if even as here circumscribed and limited it should appear to some poor-spirited person a vast work, let him turn to the libraries ; and there among other things let him look at the bodies of civil and canonical law on one side, and at the commentaries of doctors and lawyers on the other ; and see what a difference there is between the two in point of mass and volume. For we (who as faithful secretaries do but enter and set down the laws themselves of nature and nothing else) are content with brevity, and almost compelled to it by the condition of things ; whereas opinions, doctrines, and speculations are without number and without end.

And whereas in the Plan of the Work I have spoken of the *Cardinal Virtues* in nature, and said that a history of these must also be collected and written before we come to the work of Interpretation ; I have not forgotten this, but I reserve this part for myself ; since until men have begun to be somewhat more closely intimate with nature, I cannot venture to rely very much on other people's industry in that matter.

And now should come the delineation of the particular histories. But I have at present so many other things to do that I can only find time to subjoin a Catalogue of their titles. As soon however as I have leisure for it, I mean to draw up a set of questions on the several subjects, and to explain what points with regard to each of the histories are especially to be inquired and collected, as conducing to the end I have in view,—like a kind of particular Topics. In other words, I mean (according to the practice in civil causes) in this great Plea or Suit granted by the divine favour and providence (whereby the human race seeks to recover its right over nature), to examine nature herself and the arts upon interrogatories.

CATALOGUE OF PARTICULAR HISTORIES BY TITLES.

1. History of the Heavenly Bodies ; or Astronomical History.
2. History of the Configuration of the Heaven and the parts thereof towards the Earth and the parts thereof ; or Cosmographical History.
3. History of Comets.
4. History of Fiery Meteors.
5. History of Lightnings, Thunderbolts, Thunders, and Coruscations.
6. History of Winds and Sudden Blasts and Undulations of the Air.
7. History of Rainbows.
8. History of Clouds, as they are seen above.
9. History of the Blue Expanse, of Twilight, of Mock-Suns, Mock-Moons, Haloes, various colours of the Sun ; and of every variety in the aspect of the heavens caused by the medium.
10. History of Showers, Ordinary, Stormy, and Prodigious ; also of Water-Spouts (as they are called) ; and the like.
11. History of Hail, Snow, Frost, Hoar-frost, Fog, Dew, and the like.
12. History of all other things that fall or descend from above, and that are generated in the upper region.
13. History of Sounds in the upper region (if there be any), besides Thunder.
14. History of Air as a whole, or in the Configuration of the World.
15. History of the Seasons or Temperatures of the Year, as well according to the variations of Regions as according to accidents of Times and periods of Years ; of Floods, Heats, Droughts, and the like.
16. History of Earth and Sea ; of the Shape and Compass of them, and their Configurations compared with each other ; and of their broadening or narrowing ; of Islands in the Sea ; of Gulfs of the Sea, and Salt Lakes within the Land ; Isthmuses and Promontories.
17. History of the Motions (if any be) of the Globe of Earth and Sea ; and of the Experiments from which such motions may be collected.
18. History of the greater Motions and Perturbations in Earth and Sea ; Earthquakes, Tremblings and Yawnings of the Earth, Islands newly appearing ; Floating Islands ; Breaking off of Land by entrance of the Sea, Encroachments and Inundations and contrariwise Recessions of the Sea ; Eruptions of Fire from the Earth ; Sudden Eruptions of Waters from the Earth ; and the like.
19. Natural History of Geography ; of Mountains, Vallies, Woods, Plains, Sands, Marches, Lakes, Rivers, Torrents, Springs, and every variety of their course, and the like ; leaving apart Nations, Provinces, Cities, and such like matters pertaining to Civil life.
20. History of Ebbs and Flows of the Sea ; Currents, Undulations, and other Motions of the Sea.
21. History of the other Accidents of the Sea ; its Saltness, its various Colours, its Depth ; also of Rocks, Mountains and Vallies under the Sea, and the like.

Next come Histories of the Greater Masses.

22. History of Flame and of things Ignited.
23. History of Air, in Substance, not in the Configuration of the World.
24. History of Water, in Substance, not in the Configuration of the World.
25. History of Earth and the diversity thereof, in Substance, not in the Configuration of the World.

Next come Histories of Species.

26. History of perfect Metals, Gold, Silver ; and of the Mines, Veins, Marcasites of the same ; also of the Working in the Mines.
27. History of Quicksilver.
28. History of Fossils ; as Vitriol, Sulphur, etc.
29. History of Gems ; as the Diamond, the Ruby, etc.
30. History of Stones ; as Marble, Touchstone, Flint, etc.
31. History of the Magnet.
32. History of Miscellaneous Bodies, which are neither entirely Fossil nor Vegetable ; as Salts, Amber, Ambergris, etc.
33. Chemical History of Metals and Minerals.
34. History of Planets, Trees, Shrubs, Herbs ; and of their parts, Roots, Stalks, Wood, Leaves, Flowers, Fruits, Seeds, Gums, etc.
35. Chemical History of Vegetables.
36. History of Fishes, and the Parts and Generation of them.
37. History of Birds, and the Parts and Generation of them.
38. History of Quadrupeds, and the Parts and Generation of them.
39. History of Serpents, Worms, Flies, and other insects ; and of the Parts and Generation of them.
40. Chemical History of the things which are taken by Animals.

Next come Histories of Man.

41. History of the Figure and External Limbs of Man, his Stature, Frame, Countenance and Features ; and of the variety of the same according to Races and Climates, or other smaller differences.
42. Physiognomical History of the same.
43. Anatomical History, or of the Internal Members of Man ; and of the variety of them, as it is found in the Natural Frame and Structure, and not merely as regards Diseases and Accidents out of the course of Nature.
44. History of the Parts of Uniform Structure in Man ; as Flesh, Bones, Membranes, etc.
45. History of Humours in Man ; Blood, Bile, Seed, etc.
46. History of Excrements ; Spittle, Urine, Sweats, Stools, Hair of the Head, Hairs of the Body, Whitlows, Nails, and the like.
47. History of Faculties ; Attraction, Digestion, Retention, Expulsion, Sanguification, Assimilation of Aliment into the members, conversion of Blood and Flower of Blood into Spirit, etc.
48. History of Natural and Involuntary Motions ; as Motion of the Heart, the Pulses, Sneezing, Lungs, Erection, etc.
49. History of Motions partly Natural and partly Violent ; as of Respiration, Cough, Urine, Stool, etc.
50. History of Voluntary Motions ; as of the Instruments of Articulation of Words ; Motions of the Eyes, Tongue, Jaws, Hands, Fingers ; of Swallowing, etc.
51. History of Sleep and Dreams.
52. History of different habits of Body—Fat, Lean ; of the Complexions (as they call them), etc.
53. History of the Generation of Man.
54. History of Conception, Vivification, Gestation in the Womb, Birth, etc.
55. History of the Food of Man ; and of all things Eatable and Drinkable ; and of all Diet ; and of the variety of the same according to nations and smaller differences.
56. History of the Growth and Increase of the Body, in the whole and in its parts.
57. History of the Course of Age ; Infancy, Boyhood, Youth, Old Age ; of Length and Shortness of Life, and the like, according to nations and lesser differences.
58. History of Life and Death.
59. History Medicinal of Diseases, and the Symptoms and Signs of them.

60. History Medicinal of the Treatment and Remedies and Cures of Diseases.
61. History Medicinal of those things which preserve the Body and the Health.
62. History Medicinal of those things which relate to the Form and Comeliness of the Body.
63. History Medicinal of those things which alter the Body, and pertain to Alterative Regimen.
64. History of Drugs.
65. History of Surgery.
66. Chemical History of Medicines.
67. History of Vision, and of things Visible.
68. History of Painting Sculpture, Modelling, etc.
69. History of Hearing and Sound.
70. History of Music.
71. History of Smell and Smells.
72. History of Taste and Tastes.
73. History of Touch, and the objects of Touch.
74. History of Venus, as a species of Touch.
75. History of Bodily Pains, as species of Touch.
76. History of Pleasure and Pain in general.
77. History of the Affections ; as Anger, Love, Shame, etc.
78. History of the Intellectual Faculties ; Reflexion, Imagination, Discourse, Memory, etc.
79. History of Natural Divinations.
80. History of Diagnostics, or Secret Natural Judgments.

81. History of Cookery, and the arts thereto belonging, as of the Butcher, Poulterer, etc.
82. History of Baking, and the Making of Bread, and the arts thereto belonging, as of the Miller, etc.
83. History of Wine.
84. History of the Cellar and of different kinds of Drink.
85. History of Sweetmeats and Confections.
86. History of Honey.
87. History of Sugar.
88. History of the Dairy.
89. History of Baths and Ointments.
90. Miscellaneous History concerning the care of the body,—as of Barbers, Perfumers, etc.
91. History of the working of Gold, and the arts thereto belonging.
92. History of the manufactures of Wool, and the arts thereto belonging.
93. History of the manufactures of Silk, and the arts thereto belonging.
94. History of manufactures of Flax, Hemp, Cotton, Hair, and other kinds of Thread, and the arts thereto belonging.
95. History of manufactures of Feathers.
96. History of Weaving, and the arts thereto belonging.
97. History of Dyeing.
98. History of Leather-making, Tanning, and the arts thereto belonging.
99. History of Ticking and Feathers.
100. History of working in Iron.
101. History of Stone-cutting.
102. History of the making of Bricks and Tiles.
103. History of Pottery.
104. History of Cements, etc.
105. History of working in Wood.
106. History of working in Lead.
107. History of Glass and all vitreous substances, and of Glass-making.
108. History of Architecture generally.
109. History of Waggons, Chariots, Litters, etc.
110. History of Printing, of Books, of Writing, of Sealing ; of Ink, Pen, Paper, Parchments, etc.

111. History of Wax.
112. History of Basket-making.
113. History of Mat-making, and of manufactures of Straw, Rushes, and the like.
114. History of Washing, Scouring, etc.

115. History of Agriculture, Pasturage, Culture of Woods, etc.
116. History of Gardening.
117. History of Fishing.
118. History of Hunting and Fowling.
119. History of the Art of War, and of the arts thereto belonging, as Armoury, Bow-making, Arrow-making, Musketry, Ordinance, Cross-bows, Machines, etc.
120. History of the Art of Navigation, and of the crafts and arts thereto belonging.
121. History of Athletics and Human Exercises of all kinds.
122. History of Horsemanship.
123. History of Games of all kinds.
124. History of Jugglers and Mountebanks.
125. Miscellaneous History of various Artificial Materials,—as Enamel, Porcelain, various Cements, etc.
126. History of Salts.
127. Miscellaneous History of various Machines and Motions.
128. Miscellaneous History of Common Experiments which have not grown into an Art.

Histories must also be written of Pure Mathematics ; though they are rather observations than experiments.

129. History of the Natures and Powers of Numbers.
130. History of the Natures and Powers of Figures.

It may not be amiss to observe that, whereas many of the experiments must come under more titles than one (as the History of Plants and the History of the Art of Gardening have many things in common), it will be more convenient to investigate them with reference to Arts, and to arrange them with reference to Bodies. For I care little about the mechanical arts themselves : only about those things which they contribute to the equipment of philosophy. But these things will be better regulated as the case arises.

OF THE DIGNITY AND ADVANCEMENT OF LEARNING[1]

Books II.—IX.

PREFACE.

BY JAMES SPEDDING.

In a letter dated June 30, 1622, Bacon speaks of the *De Augmentis Scientiarum* as a work already in the hands of translators, and likely to be finished by the end of the summer. "Librum meum de progressu Scientiarum traducendum commisi. Illa translatio, volente Deo, sub finem æstatis perficietur.[2]" Therefore though it was not published till the autumn of 1623, it may be considered as coming, in order of composition, next among the Philosophical works to the *Novum Organum* and *Parasceve*.

It was intended to serve for the first part of the Instauratio Magna, according to the plan laid out in the *Distributio Operis*—the part which is there entitled *Partitiones Scientiarum*, and described as exhibiting a complete survey of the world of human knowledge as it then was—"Scientiæ ejus sive doctrinæ in cujus possessione humanum genus hactenus versatur summam sive descriptionem universalem". The relation which it bears to the rest of the work is best explained in the dedicatory letter prefixed to the *Dialogue of a Holy War*. "And again, for that my book of Advancement of Learning may be some preparative or key for the better opening of the Instauration, because it exhibits a mixture of new conceits and old, whereas the Instauration gives the new unmixed, otherwise than with some aspersion of the old for taste's sake, I have thought good to procure a translation of that book into the general language, not without great and ample additions and enrichment thereof, especially in the second book, which handleth the partition of sciences; in such sort as I hold it [3] may serve in lieu of the first part of the Instauration, and acquit my promise in that part."

But why, when Bacon determined to fit this work for that part, did he not give it the proper title? Curious as he always was in the choice of names, why not call it "*Partitiones* Scientiarum", which describes the proper business of the first part of the Instauratio, instead of "De *dignitate et augmentis* Scientiarum", which passes it by?

The answer, I think, is that he felt it would be inappropriate. The form in which the *De Augmentis* was cast retained so strong an impress of the original design out of which it grew,—a design truly and exactly described in the title, and having no immediate reference to the ultimate plan of the Instauratio—that another title referring to another design would have been manifestly unfit. When he wrote the Advancement of Learning, he was already engaged upon a work concerning the Interpretation of Nature, which (to judge from the fragments and sketches that remain) was meant to begin at once where the *Novum Organum* begins, without any preliminary review of the existing condition of knowledge.

[1] Translation of the *De Dignitate et Augmentis Scientiarum*.

[2] Letter to Father Redempt. Baranzan.

[3] That is, the second book; as appears more clearly from the Latin version of this letter, which was written later. "Idque ita cumulate præstiti ut judicem *librum illum jam in plures divisum*, pro primâ Instaurationis parte haberi posse, quam *Partitionum Scientiarum* nomine antea insignivi."

a work corresponding to that which in the foregoing extract he calls "the Instauration", as distinguished from the Advancement of Learning, which was to serve as "a preparative or key" to it; and the writing of a book which should exhibit a complete and particular survey of the state of knowledge then extant in the world was, I suspect, a by-thought suggested by a particular accident.

However Bacon may have underrated the difficulties of the reform which he proposed, he was well aware that it could not be carried into effect by a private man. A private man might suggest the course, and produce a specimen; but the execution of the work on a scale of adequate magnitude required the means and influence of a King or Pope. Now it happened, by a very singular accident, that while he was engaged in considering and maturing his plan, there succeeded to the throne of England a man whose tastes and previous training qualified him more than most other men to take an earnest, active, and intelligent interest in it. James the First was a man of peace by principle and inclination, of solid, various, and extensive learning, and of great intellectual activity. It is difficult even now to say why he might not have proved, in the province of letters, a great governor. At that time, when his faults were not yet known, he must have appeared like the very man for such an office. To Bacon it would naturally seem an object of the first importance to engage him, if possible, as a patron of the new philosophy; and, as men's minds are most impressible in times of transition, he would wish to lose no time in attempting to give his ambition a turn in that direction, while his fortune was fresh, his course unsettled, his imagination excited and open to great ideas. For this purpose, however, the work on the Interpretation of Nature was not forward enough to be available, nor very fit perhaps in itself, had it been more forward than it was. The idea was too new, the scheme too vast, the end too remote, to engage the serious attention of a king nearly forty years old, who had been bred in the ancient learning and attained a proficiency in it of which he was proud. "Restat unica salus ac sanitas ut opus mentis universum de integro resumatur" was an avowal which might well startle him. Not so a work representing the state of human science as it was, and the means of perfecting and extending it in many new directions. This lay in James's own province; of the review of what had been already done few men of his time were better qualified to judge; few perhaps were more likely to be attracted and excited by the prospect of doing more. Now Bacon's own travels in search of the light he had been looking for had carried him over the whole surface of the intellectual globe; and he was therefore well qualified to report upon the condition of it,—to declare how far and in what directions the dominion of knowledge had been already advanced, what regions were still unexplored and unsubdued, and what measures might best be taken to bring them into subjection. Such a representation was likely enough to make an impression on a mind constituted and trained like that of James the First. Possibly it might even rouse him to take up the extension of knowledge as a royal business; in which case the new philosophy would have started with advantages not otherwise to be hoped for.

This work therefore Bacon seems to have set about at once. There is reason to believe that the first book of the Advancement of Learning, which treats of the excellence and dignity of knowledge as a pursuit for kings and statesmen, was written in 1603, immediately after James's accession; and the second, which treats of the deficiencies remaining and the supplies required, in 1605; the intervening year of 1604 having been too much occupied with civil business to allow much leisure for the prosecution of a work of that kind. It was important to push it forward as fast as possible, even at the expense of completeness: for the very object for which I suppose it to have been undertaken,—that of making an impression on the king's mind while it was in the best state to receive impressions,—would have been lost by delay; and accordingly in the autumn of 1605 appeared "the Twoo Bookes of Francis Bacon, of the proficience and advancement of Learning, divine and humane"; with many marks of haste in form and composition, and even in substance not altogether adequate to the argument in hand, but nevertheless well enough adapted for its immediate purpose, if I have rightly conjectured what that purpose was.

If this be the true history of the Advancement of Learning, the rest follows naturally. The stroke, though well aimed, was not successful. The book may have raised James's opinion of Bacon, but it did not inspire him with any zeal for the Great Instauration. There it was, however; and it contained such a quantity of the best fruits of Bacon's mind, and so many new views bearing on the great reform which he meditated, that it seemed a pity not to find a place for it in the great work. This was easily done by enlarging the original design so as to include a preliminary survey of the existing state of knowledge; in which case the substance of the second book of the Advancement might do duty as the first part of the Instauratio Magna. If we knew when the fragment entitled *Partis Instaurationis Secundæ Delineatio* was written, we might almost fix the time at which this enlargement of the original design was resolved upon. For in that fragment Bacon proposes to distribute the whole subject of the Interpretation of Nature through the second, third, fourth, fifth, and sixth parts of the work, exactly as in the *Distributio Operis*; a place being reserved for a first part, though the nature of its contents is not specified. And from the *Descriptio Globi Intellectualis*, which was written in 1612, and appears, as I have elsewhere remarked, to be a commencement of the *Partitiones Scientiarum* itself, we may partly infer the form in which he then intended to cast that part.

Why he afterwards altered his intention and resolved to content himself with a mere translation of the two books of the Advancement with additions, it is not difficult to conjecture, if we take into account the circumstances of his life. When the *Novum Organum* was published in October 1620, the king had just resolved to call a new Parliament after six years' intermission, and questions of vital interest both at home and abroad hung upon the issue of it. The necessary preparations for the session, Bacon's own impeachment, which almost immediately followed, a severe illness consequent upon that, his condemnation and imprisonment, negotiations with importunate creditors, and the composition of the *History of Henry the Seventh*, which was finished in October 1621, must have given him occupation enough during the next twelve months. Then came the question, how he was to proceed with the Instauratio, so as to make the most of such time and means as remained. Sixty-two years old, with health greatly impaired, an income scarcely sufficient to live upon, and an establishment of servants much reduced, he could not afford to waste labour upon things not essential. The Novum Organum was not half finished. The Natural History was not even begun, and no fellow-labourer had yet come forward to help in it [4]. It was only in the completion of the first of the six parts that he could hope for material assistance from others. Even this, if he had attempted to recast it in the form which I suppose him to have designed,—the form indicated in the *Descriptio Globi Intellectualis*,—he could hardly have executed by deputy; whereas a translation of the Advancement of Learning might be so executed, and would need only corrections and additions to make it a complete survey of the intellectual globe, adequate in substance to its place, though not symmetrical in form. Accordingly, "by help of some good pens which did not forsake him," he proceeded at once to put this in train, and then turned his own attention to the Natural History, which he considered as "*basis totius negotii*".

Concerning the causes which delayed the publication of the *De Augmentis* a twelvemonth beyond the expected time, I have no information. But it is probable that the additions which suggested themselves as he proceeded were far larger than he had anticipated; being indeed in the second book as much again as the original, and more. The measures which he took however were in this instance quite successful; and by sacrificing a little symmetry of form, he succeeded in effectually preserving the substance of this first part of his great work [5].

[4] "Neque huic rei deero quantum in me est. Utinam habeam et adjutores idoneos." —*Letter to Father Redempt. Baranzan*, 30 June, 1622.

[5] The volume in which it originally appeared bore the following general title-page: *Opera Francisci Baronis de Verulamio, vice-comitis Sancti Albani. Tomus primus. Qui continet* De Augmentis Scientiarum *libros IX. Ad regem suum. Londini, in officina*

Tenison mentions "Mr. Herbert"—that is, George Herbert, the poet—as one of the translators employed. But we have it upon Rawley's authority that Bacon took a great deal of pains with it himself (proprio marte plurimum desudavit)—so that we must consider the whole translation as stamped with his authority. Many years before he had asked Dr. Playfer to do it; who (according to Tenison) sent him a specimen, but "of such superfine Latinity, that the Lord Bacon did not encourage him to labour further in that work, in the penning of which he desired not so much neat and polite, as clear masculine and apt expression" [6]. And it is not improbable that some such difficulty may have occurred. But Playfer's failure may be sufficiently accounted for by the state of his health. A memorandum in the *Commentarius Solutus* dated 26 July, 1608—"Proceeding with the translation of my book of Advancement of Learning—hearkening to some other if Playfer should fail,"—shows that at that time it was still in his hands; and he died at the beginning of the next year.

I have only to add that all the notes to this work which bear no signature are Mr. Ellis's, except such parts of them as are inserted within brackets. These, as well as all notes signed J. S., are mine.

J. S.

Joannis Haviland, MDCXXIII. But this had reference to a collection (which he then meditated) of all his works, in Latin; not to the order of the *Instauratio*, which was not in a condition to be published consecutively. See *Epistola ad Fulgentium*: Opuscula, p. 172.

[6] Baconiana, p. 26.

THE DIVISIONS OF THE SCIENCES, AND ARGUMENTS OF THE SEVERAL CHAPTERS.

BOOK THE SECOND.

CHAP. I.

DIVISION of all Human Learning into *History, Poesy, Philosophy ;* with reference to the three Intellectual Faculties, *Memory, Imagination, Reason ;* and that the same division holds good likewise in Theology.

CHAP. II.

Division of History into *Natural* and *Civil ; Ecclesiastical* and *Literary* History being included in Civil. Division of Natural History, according to its subject, into History of *Generations, Preter-generations*, and *Arts*.

CHAP. III.

Second division of Natural History, according to its use and end, into *Narrative* and *Inductive ;* and that the noblest end of Natural History is to minister and be in order to *the building up of Philosophy ;* which end is aimed at by the *Inductive*. Division of the History of Generations into the History of the *Heavenly Bodies*, of *Meteors*, of *the Globe of Earth and Sea*, of *the Masses* or *Greater Colleges*, and of *the Species* or *Lesser Colleges*.

CHAP. IV.

Division of Civil History into *Ecclesiastical, Literary*, and *Civil* (properly so called) : and that *Literary History* is wanting. Precepts for the construction thereof.

CHAP. V.

Of the dignity and difficulty of Civil History.

CHAP. VI.

First division of Civil History (properly so called) into *Memorials, Antiquities*, and *Perfect History*.

CHAP. VII.

Division of Perfect History into *Chronicles of Times, Lives of Persons, and Relations of Actions*. The explanation of these.

CHAP. VIII.

Division of History of Times into *Universal* and *Particular*. The advantages and disadvantages of each.

CHAP. IX.

Second division of History of Times into *Annals* and *Journals*.

CHAP. X.

Second division of Civil History (properly so called) into *Pure* and *Mixed*.

CHAP. XI.

Division of Ecclesiastical History, into History of the *Church*, History according to the *Prophecies*, and History of *Providence*.

CHAP. XII.

Of certain *Appendices to History*, which deal with the *words* of man, as History deals with their actions. Division of the same into *Orations, Letters*, and *Apophthegms*.

CHAP. XIII

Of the second principal branch of Learning, namely, *Poesy*. Division of Poesy into *Narrative*, *Dramatic*, and *Parabolical*. Three examples of Parabolical Poesy are propounded.

BOOK THE THIRD.

CHAP. I.

Division of Science into *Theology* and *Philosophy*. Division of Philosophy into three doctrines; concerning the *Deity*, concerning *Nature*, and concerning *Man*. Constitution of *Primary Philosophy* as the common mother of all.

CHAP. II.

Of *Natural Theology*; and the doctrine concerning *Angels* and *Spirits*, which is an appendix of the same.

CHAP. III.

Division of Natural Philosophy into *Speculative* and *Operative*. And that these two ought to be kept separate, both in the intention of the writer and in the body of the treatise.

CHAP. IV.

Division of Speculative doctrine concerning nature, into *Physic* (special) and *Metaphysic*. Whereof Physic inquires of the *Efficient Cause* and the *Material*; Metaphysic of the *Final Cause* and the *Form*. Division of Physic (special) into doctrine concerning *the Principles of Things*, concerning the *Fabric of Things*, or the world; and concerning the *Variety of Things*. Division of the doctrine concerning the Variety of Things into doctrine concerning things *concrete*, and doctrine concerning things *abstract*. The division of the doctrine concerning things concrete is referred to the same divisions which Natural History receives. Division of the doctrine concerning things abstract, into doctrine concerning the *Configuration of Matter*, and the doctrine concerning *motions*. Two appendices of Speculative Physic: *natural problems*, and *dogmas of the ancient philosophers*. Division of Metaphysic into doctrine concerning *Form*, and doctrine concerning *Final Causes*.

CHAP. V.

Division of the operative doctrine concerning Nature into *Mechanic* and *Magic*, which correspond to the divisions of the speculative doctrine: *Mechanic* answering to *Physic*, *Magic* to *Metaphysic*. Purification of the word Magic. Two appendices of the operative doctrine. *Inventory of the possessions of man*; and *Catalogue of Polychrests*, or things of general use.

CHAP. VI.

Of the great Appendix of Natural Philosophy, both speculative and operative, namely *Mathematics*: and that it ought rather to be placed among appendices than among substantive science. Division of Mathematics into *Pure* and *Mixed*.

BOOK THE FOURTH.

CHAP. I.

Division of the doctrine concerning Man into *Philosophy of Humanity* and *Philosophy Civil*. Division of the Philosophy of Humanity into doctrine concerning the *Body of Man*, and doctrine concerning the *Soul of Man*. Constitution of one general doctrine concerning the *Nature* or the *State of Man*. Division of the doctrine concerning the State of Man into doctrine concerning the *Person of Man*, and concerning the *League of Mind and Body*. Division of the doctrine concerning the Person of Man into doctrine concerning the *Miseries of Man*, and concerning his *Prerogatives*. Division of the doctrine concerning the League, into doctrine concerning *Indications* and concerning *Impressions*. Assignation of *Physiognomy* and *Interpretation of Natural Dreams* to the doctrine concerning Indications.

CHAP. II.

Division of the doctrine concerning the Body of Man into *Medicine, Cosmetic, Athletic,* and *Voluptuary.* Division of Medicine into three offices ; viz. the *Preservation of Health,* the *Cure of Diseases,* and the *Prolongation of Life.* And that the last division concerning the prolongation of Life ought to be kept separate from the other two.

CHAP. III.

Division of Human Philosophy relating to the Soul into doctrine concerning the *Breath of Life* and doctrine concerning the *Sensible or Produced Spirit.* Second division of the same Philosophy into doctrine concerning the *Substance and Faculties of the Soul,* and doctrine concerning the *Use and Objects of the Faculties.* Two appendices to the doctrine concerning the Faculties of the Soul : doctrine concerning *Natural Divination,* and doctrine concerning *Fascination.* Distribution of the faculties of the Sensible Soul into *Motion* and *Sense.*

BOOK THE FIFTH.

CHAP. I.

Division of the doctrine concerning the use and objects of the Faculties of the Human Soul into *Logic* and *Ethics.* Division of Logic into the arts of *Discovering,* of *Judging,* of *Retaining,* and of *Transmitting.*

CHAP. II.

Division of the Art of Discovering into discovery of *Arts* and discovery of *Arguments* and that the former of these (which is the most important) is wanting. Division of the art of discovery of Arts into *Learned Experience* and the *New Organon.* Description of *Learned Experience.*

CHAP. III.

Division of the art of discovery of Arguments into the *Promptuary,* and *Topics.* Division of Topics into *General* and *Particular.* Example of a Particular Topic, in an inquiry concerning Heavy and Light.

CHAP. IV.

Division of the art of Judging into judgment by *Induction* and judgment by *Syllogism.* The first whereof is referred to the New Organon. First division of Judgment by Syllogism into *Reduction Direct* and *Reduction Inverse.* Second division of the same into *Analytic,* and doctrine concerning *Detection of Fallacies.* Division of the doctrine concerning the detection of fallacies into detection of *sophistical* fallacies, fallacies *of interpretation,* and fallacies of *false appearances or Idols.* Division of Idols into Idols of the *Tribe,* Idols of the *Cave,* and Idols of the *Market-place.* Appendix to the Art of Judging ; viz. concerning *the Analogy of Demonstrations according to the nature of the subject.*

CHAP. V.

Division of the Art of Retaining into the doctrine concerning the *Helps of Memory* and the doctrine concerning *Memory itself.* Division of the doctrine concerning Memory itself into *Prenotion* and *Emblem.*

BOOK THE SIXTH.

CHAP. I.

Division of the art of Transmitting into the doctrine concerning the *Organ of Discourse,* the doctrine concerning the *Method of Discourse,* and the doctrine concerning the *Illustration of Discourse.* Division of the doctrine concerning the organ of discourse into the doctrine concerning the *Notations of Things,* concerning *Speech,* and concerning *Writing.* Whereof the two first constitute *Grammar* and are divisions of it. Division of the doctrine concerning the notations of things into *Hieroglyphics,* and *Real Characters.* Second division of Grammar into *Literary* and *Philosophic.* Reference of *Poesy in respect of metre* to the doctrine concerning *Speech.* Reference of the doctrine concerning *ciphers* to the doctrine concerning *Writing.*

CHAP. II.

The doctrine concerning the *Method of Discourse* is made a substantive and principal part of the art of *transmitting ;* and is named *Wisdom of Transmission.* Different kinds of method are enumerated, with a note of their advantages and disadvantages.

CHAP. III.

Of the foundations and office of the doctrine concerning Illustration of Discourse, or Rhetoric. Three appendices of Rhetoric, which relate only to the *Promptuary ; Colours of Good and Evil,* both simple and comparative ; *Antitheses of things ; Lesser Forms of Speeches.*

CHAP. IV.

Two general appendices of the Art of Transmission ; *Critical* and *Pedagogical.*

BOOK THE SEVENTH.

CHAP. I.

Division of Moral Knowledge into the *Exemplar* or *Platform of Good,* and the *Georgics* or *Culture of the Mind.* Division of the Platform of Good into *Simple* and *Comparative Good.* Division of Simple Good into *Individual* Good, and Good of *Communion.*

CHAP. II.

Division of Individual or Self-Good into *Active* and *Passive Good.* Division of *Passive Good* into *Conservative* and *Perfective Good.* Division of the *Good of Communion* into *General* and *Respective Duties.*

CHAP. III.

Division of the doctrine concerning the *Culture of the Mind* into the doctrine concerning the *Characters of Minds,* the *Affections,* and the *Remedies* or *Cures.* Appendix of this same doctrine, touching the *Congruity between the Good of the Mind and the Good of the Body.*

BOOK THE EIGHTH.

CHAP. I.

Division of Civil Knowledge into the doctrine concerning *Conversation, Negotiation,* and *Empire* or *State Government.*

CHAP. II.

Divison of the doctrine concerning Negotiation into the doctrine concerning *Scattered Occasions* and the doctrine concerning *Advancement in Life.* Example of the doctrine concerning Scattered Occasions from some of the Proverbs of Solomon. Precepts concerning Advancement in Life.

CHAP. III.

The divisions of the doctrine concerning Empire or Government are omitted ;—An Introduction only is made to two Deficients ; namely, the doctrine concerning the *Extension of the Bounds of Empire,* and the doctrine concerning *Universal Justice,* or the *Fountains of Law.*

BOOK THE NINTH.

CHAP. I.

The divisions of Inspired Divinity are omitted ;—Introduction only is made to three Deficients ; namely, the doctrine concerning the *Legitimate Use of the Human Reason in Divine Subjects ;* the doctrine concerning the *Degrees of Unity in the Kingdom of God ;* and the *Emanations of the Scriptures.*

TRANSLATION OF THE

DE AUGMENTIS SCIENTIARUM

Book II.[1]

TO THE KING.[2]

It might seem to have more convenience, excellent King, though it come often otherwise to pass, that those who are fruitful in their generations, and have as it were the foresight of immortality in their descendants, should likewise be more careful than other men of the good estate of future times, to which they know they must transmit these their dearest pledges. Queen Elizabeth, rather a sojourner in the world than an inhabitant, in respect of her unmarried life, was an ornament to her own times and prospered them in many ways. But to your Majesty (whom God in His goodness has already blessed with so much royal issue, worthy to continue and represent you for ever, and whose youthful and fruitful bed still promises more[3]) it is proper and convenient not only to shed a lustre (as you do) on your own age, but also to extend your care to those things which all memory may preserve and which are in their nature eternal. Amongst which (if affection for learning transport me not) there is not any more noble or more worthy than the further endowment of the world with sound and fruitful knowledge. For how long shall we let a few received authors stand up like Hercules' columns, beyond which there shall be no sailing or discovery in science, when we have so bright and benign a star as your Majesty to conduct and prosper us?

To return then to the matter in hand: let us now review and consider with ourselves what has hitherto been done by kings and others for the increase and advancement of learning, and what has been left undone; and let us discuss the question solidly and distinctly, in a style active and masculine, without digressing or dilating. We may begin then by assuming (which will not be disputed) that all the greatest and most difficult works are overcome either by amplitude of reward, or by prudence and soundness of direction, or by conjunction of labours; whereof the first stimulates endeavour, the second removes uncertainty and error, and the third supplies the frailty of man. But of these three, prudence and soundness of direction,—that is, the pointing out and setting forth of the straight and ready way to the thing which is to be done,—must be placed first. For the cripple in the right way (as the saying is) outstrips the runner in the wrong. And Solomon observes, most aptly to the point in question, that "if the iron be blunt it requireth more strength, but wisdom is that which prevaileth"[4]; signifying that the prudent choice of the mean is more effectual for the purpose than either the enforcement or the accumulation of endeavours. This I am induced to say, for that (not derogating from the honour of those who have been in any way deservers towards the state of learning) I observe nevertheless that most of their works and acts have had in view rather their own magnificence and memory than the progress and advancement of learning, and have rather augmented the number of learned men than raised and rectified the sciences themselves.

[1] For the first book (which relates to the Dignity of Learning), see the "Advancement of Learning" above, pp. 43–74. The Latin differs so little from the English in that book, that a translation would be little else than a reprint. And the eight remaining books of the *De Augmentis Scientiarum*, considered as a treatise on the Divisions of the Sciences, are complete in themselves.—*J. S.*

[2] Here the first part of the *Instauratio Magna*, the *Partitiones Scientiarum*, properly begins; the nine following pages being the preface.—*J. S.*

[3] This passage, being transferred from the *Advancement of Learning*, must be considered of course as written in 1605.—*J. S.*

[4] Eccles. x. 10.

The works or acts which pertain to the advancement of learning are conversant about three objects; the places of learning, the books of learning, and the persons of the learned. For as water, whether it be the dew of Heaven or the springs of the earth, easily scatters and loses itself in the ground, except it be collected into some receptacle where it may by union and consort comfort and sustain itself (and for that cause the industry of man has devised aqueducts, cisterns, and pools, and likewise beautified them with various ornaments, for magnificence and state as well as for use and necessity); so this excellent liquor of knowledge, whether it descend from divine inspiration or spring from human sense, would soon perish and vanish into oblivion, if it were not preserved in books, traditions, and conferences; and especially in places appointed for such matters, as universities, colleges, and schools, where it may have both a fixed habitation and means and opportunity of increasing and collecting itself.

And first, the works which concern the *places of learning* are four; buildings, endowments with revenues, grants of franchises and privileges, and institutions and ordinances of government; all tending (for the most part) to retirement and quietness of life, and a release from cares and trouble; like the stations which Virgil prescribes for the hiving of honey bees.

> Principio sedes apibus statioque petenda,
> Quo neque sit ventis aditus, etc.[5]

The principal works touching *books* are two; first, libraries, which are as the shrines wherein all the relics of the ancient saints full of true virtue are preserved. Secondly, new editions of authors, with more correct impressions, more faithful translations, more profitable commentaries, more diligent annotations, and the like.

The works pertaining to the *persons of the learned* (besides the advancement and countenancing of them in general) are likewise two. The remuneration and designation of lecturers in arts already extant and invented; and the remuneration and appointment of writers and inquirers concerning those parts of learning not yet sufficiently laboured or prosecuted.

These are summarily the works and acts wherein the merits of many excellent princes and other illustrious personages towards learning have been manifested. As for the particular commemoration of any one who has deserved well of literature, I call to mind what Cicero said when, on his return from exile, he gave general thanks; "It is hard to remember all, ungrateful to pass by any"[6]. Let us rather (after the advice of Scripture) look forward to that part of the race which is still to be run, than look back to that which has been passed.

First therefore, among so many noble foundations of colleges in Europe, I find it strange that they are all dedicated to professions, and none left free to the study of arts and sciences at large. For if men judge that learning should be referred to use and action, they judge well; but it is easy in this to fall into the error pointed at in the ancient fable; in which the other parts of the body found fault with the stomach, because it neither performed the office of motion as the limbs do, nor of sense, as the head does; but yet notwithstanding it is the stomach which digests and distributes the aliment to all the rest. So if any man think that Philosophy and Universality are idle and unprofitable studies, he does not consider that all arts and professions are from thence supplied with sap and strength. And this I take to be a great cause, which has so long hindered the more flourishing progress of learning; because these fundamental knowledges have been studied but in passage, and not drunk deeper of. For if you will have a tree bear more fruit than it has used to do, it is not anything you can do to the boughs, but it is the stirring of the earth, and putting richer mould about the roots, that must work it. Neither is it to be forgotten that this dedication of colleges and societies to the use only of professory learning has not only

[5] Virg. *Georg.* iv. 8.:—First for thy bees a quiet station find,
And lodge them under covert of the wind.

[6] Cicero, *Post Red.* c. 12.

been inimical to the growth of the sciences, but has also been prejudicial to states and governments. For hence it proceeds that princes when they have to choose men for business of state find a wonderful dearth of able men around them; because there is no collegiate education designed for these purposes, where men naturally so disposed and affected might (besides other arts) give themselves especially to histories, modern languages, books of policy and civil discourse; whereby they might come better prepared and instructed to offices of state.

And because founders of Colleges do plant, and founders of Lectures do water, I must next speak of the deficiencies which I find in public lectures; wherein I especially disapprove of the smallness of the salary assigned to lecturers in arts and professions, particularly amongst ourselves. For it is very necessary to the progression of sciences that lecturers in every sort be of the most able and sufficient men; as those who are ordained not for transitory use, but for keeping up the race and succession of knowledge from age to age. This cannot be, except their condition and endowment be such that the most eminent professors may be well contented and willing to spend their whole life in that function and attendance, without caring for practice. And therefore if you will have sciences flourish, you must observe David's military law; which was, "That those who stayed with the baggage should have equal part with those who were in the action"[7]; else will the baggage be ill attended. So lecturers in sciences are as it were the keepers and guardians of the whole store and provision of learning, whence the active and militant part of the sciences is furnished; and therefore they ought to have equal entertainment and profit with the men of active life. Otherwise if the fathers in sciences be not amply and handsomely maintained, it will come to pass, as Virgil says of horses,—

Et patrum invalidi referent jejunia nati[8];

the poor keeping of the parents will be seen in the weakliness of the children.

I will now notice another defect, wherein I should call in some alchemist to help me; one of those who advise the studious to sell their books and build furnaces, and forsaking Minerva and the Muses as barren virgins, to rely upon Vulcan. But certain it is that for depth of speculation no less than for fruit of operation in some sciences (especially natural philosophy and physic) other helps are required besides books. Wherein also the beneficence of men has not been altogether wanting; for we see spheres, globes, astrolabes, maps, and the like have been provided and prepared as assistants to astronomy and cosmography, as well as books. We see likewise that some places instituted for physic have gardens for the examination and knowledge of simples of all sorts, and are not without the use of dead bodies for anatomical observations. But these respect but a few things. In general, it may be held for certain that there will hardly be any great progress in the unravelling and unlocking of the secrets of nature, except there be a full allowance for expenses about experiments; whether they be experiments appertaining to Vulcan or Dædalus (that is, the furnace or engine), or any other kind. And therefore as secretaries and emissaries of princes are allowed to bring in bills of expenses for their diligence in exploring and unravelling plots and civil secrets, so the searchers and spies of nature must have their expenses paid, or else you will never be well informed of a great number of things most worthy to be known. For if Alexander made such a liberal assignation of money to Aristotle, to support hunters, fowlers, fishers and the like, that he might be better furnished for compiling a History of Animals; certainly much more do they deserve it, who instead of wandering in the forests of nature, make their way through the labyrinths of arts.

Another defect to be noticed (and one of great importance) is a neglect of consultation in governors of universities, and of visitation in princes or superior

[7] 1 Sam. xxx. 24. Similarly it was provided by the laws of Alfonso the Wise, in accordance with earlier usage, that no division of spoil should be made until those in pursuit of the enemy had returned to the camp. See the *Siete Partidas*, ii. 26. 1.

[8] *Georg.* iii. 128.

persons, to enter into careful account and consideration whether the readings, disputations, and other scholastic exercises anciently begun, and since continued up to our time, may be profitably kept up, or whether we should rather abolish them and substitute better. For I find it is one of your Majesty's most wise maxims; "That in all usages or precedents the times be considered wherein they first begun; which, if they were disordered or ignorant, it derogates greatly from the authority of the precedents, and leaves all things for suspect". And therefore inasmuch as most of the institutions of the universities are derived from times a good deal more obscure and ignorant than our own, it is the more convenient that they be re-examined. In this kind I will give an instance or two, of things which appear the most obvious and familiar. It is a general custom (and yet I hold it to be an error) that scholars come too soon and too unripe to the study of logic and rhetoric, arts fitter for graduates than children and novices; for these two rightly taken are the gravest of sciences, being the arts of arts, the one for judgment, the other for ornament; besides they give the rule and direction how both to set forth and illustrate the subject matter. And therefore for minds empty and ignorant (and which have not yet gathered what Cicero calls "stuff [9]" or "furniture [10]", that is matter and variety) to begin with those arts (as if one should learn to weigh or to measure or to paint the wind), works but this effect, that the virtue and faculty of those arts (which are great and universal) are almost made contemptible, and either degenerate into childish sophistry and ridiculous affectation, or at least lose not a little of their reputation. And further, the premature and untimely learning of these arts has drawn on, by consequence, the superficial and unprofitable teaching and handling of them,—a manner of teaching suited to the capacity of children. Another instance of an error which has long prevailed in universities is this; that they make too great and mischievous a divorce between invention and memory. For most of the speeches there are either entirely premeditate, and delivered in preconceived words, where nothing is left to invention; or merely extempore, where little is left to memory; whereas in common life and action there is little use of either of these separately, but rather of intermixtures of them; that is of notes or commentaries and extempore speech; and thus the exercise fits not the practice, nor the image the life. But it must ever be observed as a rule in exercises, that they be made to represent in everything (as near as may be) the real actions of life; for otherwise they will pervert the motions and faculties of the mind, and not prepare them. The truth whereof appears clearly enough when scholars come to the practice of their professions, or other offices of civil life; which when they set into, this want I speak of is soon found out by themselves, but still sooner by others. But this part, touching the amendment of the Institutions and Orders of Universities, I will conclude with a sentence taken from one of Cæsar's letters to Oppius and Balbus; "How this may be done, some means occur to me, and many may be found; I beg you therefore to take these matters into consideration" [11].

Another defect which I note ascends a little higher than the preceding. For as the progress of learning consists not a little in the wise ordering and institutions of each several university; so it would be yet much more advanced if there were a closer connexion and relationship between all the different universities of Europe than now there is. For we see there are many orders and societies which, though they be divided under distant sovereignties and territories, yet enter into and maintain among themselves a kind of contact and fraternity, insomuch that they have governors (both provincial and general) whom they all obey. And surely as nature creates brotherhood in families, and arts mechanical contract brotherhoods in societies, and the anointment of God superinduces a brotherhood in kings and bishops, and vows and regulations make a brotherhood in religious orders; so in like manner there cannot but be a noble and generous brotherhood contracted among men by learning and illumination, seeing that God himself is called "the Father of Lights [12]".

[9] *Sylva*, De Orator. iii. 26.
[10] *Supellex*, Orator, c. 24.
[11] Cic. Ep. ad Att. ix. 8.
[12] St. James, i. 17.

The last defect I complain of (to which I have already alluded) is that there has not been, or very rarely been, any public designation of fit men either to write or to make inquiry concerning such parts of knowledge as have not been already sufficiently laboured. To which point it will greatly conduce, if a review and *census* be made of the sciences, and account be taken what parts of them are rich and well advanced, and what poor and destitute. For the opinion of plenty is amongst the causes of want; and the great quantity of books makes a show rather of superfluity than lack; of which surcharge nevertheless the true remedy is not to destroy the old books, but to make more good ones; of such a kind that like the serpent of Moses, they may devour the serpents of the enchanters [13].

The removal of all the defects formerly enumerated, except the last, and of the active part also of the last, which relates to the designation of writers, are truly works for a king; towards which the endeavours and industry of a private man can be but as an image in a crossway, that may point at the way but cannot go it. But the speculative part of it, which relates to the survey of knowledges to see what in each is deficient, is open likewise to private industry. Wherefore I now intend to make a general and faithful perambulation and survey of learning, with a very careful and accurate inquiry what parts thereof lie fresh and waste, and not yet improved and converted to use by the industry of man; to the end that such a plot marked out, and recorded to memory, may minister light both to public designations and voluntary endeavours. Wherein nevertheless my purpose is at this time to note only omissions and deficiencies, and not to make any redargution of errors and failures; for it is one thing to point out what parts lie untilled, and another thing to mend the manner of tillage.

In addressing myself to which task I am not ignorant how great a work I attempt, and how difficult a province I take upon me; nor again how far unequal my strength is to my will. Nevertheless I have great hope that if my extreme love to learning carry me too far, I may obtain the excuse of affection; for that "it is not granted to any man at the same time to love and to be wise" [14]. But I know well I can use no other liberty of judgment, than I must leave to others; and I for my part shall be equally glad either to perform myself or to accept from others that duty of humanity, to put the wanderer on the right way: *nam qui erranti comiter monstrat viam* [15], etc. I foresee likewise that many of those things which I shall think fit to enter in this registry of mine as omitted and deficient will incur censure on different accounts; some as being already done and extant; others as savouring of curiosity, and promising very scanty fruit; others as being too difficult and almost impossible to be compassed and effected by man. For the two first I refer myself to the particulars themselves. For the last, touching impossibility, I take it that all those things are to be held possible and performable, which may be done by some persons, though not by every one; and which may be done by many together, though not by one alone; and which may be done in the succession of ages, though not in one man's life; and lastly, which may be done by public designation and expense, though not by private means and endeavour. But notwithstanding if any man will take to himself rather the saying of Solomon, "The slothful man says there is a lion in the path", [16] than that of Virgil, *Possunt, quia posse videntur*, [17] "they find it possible because they think it possible," I shall be content that my labours be esteemed but as the better sort of wishes. For as it asks some knowledge of a thing to demand a question not impertinent, so it requires some sense to make a wish not absurd.

[13] Cic. *Ep. ad Att.* ix. 8. One of the earliest tracts on the subject of university reform is doubtless that which Peter Ramus (see his *Scholæ*. Basil. 1569, p. 1063) addressed to Charles the Ninth. It relates chiefly to the expenses arising from fees, etc., to the neglect of the civil law; which had always been coldly regarded at Paris, and to the trifling manner in which the scholastic disputations were conducted.

[14] Seneca, *Proverbiæ*. [Ascribed to Laberius.]

[15] Ennius, ap. Aul. Gell. xii. 4, and ap. Cic. *De Officiis*, i. 17.

[16] Prov. xxvi. 13. [17] Virg. *Æn.* v. 231.

CHAPTER I.

The Division of all Human Learning into History, Poesy, Philosophy; *with reference to the three Intellectual Faculties,* —Memory, Imagination, *and* Reason; *and that the same division holds good likewise in* Theology.

The best division of human learning is that derived from the three faculties of the rational soul, which is the seat of learning. History has reference to the Memory, poesy to the Imagination, and philosophy to the Reason. And by poesy here I mean nothing else than feigned history or fables; for verse is but a character of style, and belongs to the arts of speech, whereof I will treat in its proper place.

History is properly concerned with individuals, which are circumscribed by place and time. For though Natural History may seem to deal with species, yet this is only because of the general resemblance which in most cases natural objects of the same species bear to one another; so that when you know one, you know all. And if individuals are found, which are either unique in their species, like the sun and moon; or notable deviations from their species, like monsters; the description of these has as fit a place in Natural History as that of remarkable men has in Civil History. All this relates to the Memory.

Poesy, in the sense in which I have defined the word, is also concerned with individuals; that is, with individuals invented in imitation of those which are the subject of true history; yet with this difference, that it commonly exceeds the measure of nature, joining at pleasure things which in nature would never have come together, and introducing things which in nature would never have come to pass; just as Painting likewise does. This is the work of Imagination.

Philosophy discards individuals; neither does it deal with the impressions immediately received from them, but with abstract notions derived from these impressions; in the composition and division whereof according to the law of nature and fact its business lies. And this is the office and work of Reason.

That these things are so, may be easily seen by observing the commencements of the intellectual process. The sense, which is the door of the intellect, is affected by individuals only. The images of those individuals—that is, the impressions which they make on the sense—fix themselves in the memory, and pass into it in the first instance entire as it were, just as they come. These the human mind proceeds to review and ruminate; and thereupon either simply rehearses them, or makes fanciful imitations of them, or analyses and classifies them. Wherefore from these three fountains, Memory, Imagination, and Reason, flow these three emanations, History, Poesy, and Philosophy; and there can be no others. For I consider history and experience to be the same thing, as also philosophy and the sciences.

Nor do I think that any other division is wanted for Theology. The information derived from revelation and the information derived from the sense differ no doubt both in the matter and in the manner of conveyance; but the human mind is the same, and its repositories and cells the same. It is only like different liquids poured through different funnels into one and the same vessel. Theology therefore in like manner consists either of Sacred History, or of Parables, which are a divine poesy, or of Doctrines and Precepts, which are a perennial philosophy. For as for that part which seems supernumerary, which is Prophecy, it is but a kind of history: for divine history has this prerogative over human, that the narration may be before the event, as well as after.

CHAPTER II.

The Division of History into Natural *and* Civil; Ecclesiastical *and* Literary *History being included in Civil. Division of Natural History into* History of Generations, Pretergenerations, *and* Arts.

HISTORY is either Natural or Civil[1]. Natural History treats of the deeds and works of nature; Civil History of those of men. Matter of Divinity shows itself no doubt in both, but principally in the latter; so much so as to form a species of history proper to itself, which I call Sacred or Ecclesiastical. And a similar distinction is in my opinion also due to Learning and the Arts—their importance being such as to entitle them to a separate history of their own. And this (as well as the Ecclesiastical) I mean to be included in Civil History.

The division which I will make of Natural History is founded upon the state and condition of nature herself. For I find nature in three different states, and subject to three different conditions of existence. She is either free, and follows her ordinary course of development; as in the heavens, in the animal and vegetable creation, and in the general array of the universe; or she is driven out of her ordinary course by the perverseness, insolence, and frowardness of matter, and violence of impediments; as in the case of monsters; or lastly, she is put in constraint, moulded, and made as it were new by art and the hand of man; as in things artificial, Let Natural History therefore be divided into the History of Generations, of Pretergenerations, and of Arts; which last I also call Mechanical and Experimental History. Of these the first treats of the Freedom of Nature, the second of her Errors, the third of her Bonds. And I am the more induced to set down the History of the Arts as a species of Natural History, because an opinion has long been prevalent, that art is something different from nature, and things artificial different from things natural; whence this evil has arisen,—that most writers of Natural History think they have done enough when they have given an account of animals or plants or minerals, omitting all mention of the experiments of mechanical arts[2]. But there is likewise another and more subtle error which has crept into the human mind; namely, that of considering art as merely an assistant to nature, having the power indeed to finish what nature has begun, to correct her when lapsing into error, or to set her free when in bondage, but by no means to change, transmute, or fundamentally alter nature. And this has bred a premature despair in human enterprises. Whereas men ought on the contrary to be surely persuaded of this; that the artificial does not differ from the natural in form or essence, but only in the efficient, in that man has no power over nature except that of motion; he can put natural bodies together, and he can separate them; and therefore that wherever the case admits of the uniting or disuniting of natural bodies, by joining (as they say) actives with passives, man can do everything; where the case does not admit this, he can do nothing. Nor matters it, provided things are put in the way to produce an effect, whether it be done by human means or otherwise. Gold is sometimes refined in the fire and sometimes found pure in the sands, nature having done the work for herself. So also the rainbow is made in the sky out of a dripping cloud; it is also made here below with a jet of water. Still therefore it is nature which governs everything: but under nature are included these three; the *course* of nature, the *wanderings* of nature, and *art*, or nature with man to help; which three must therefore all be included in Natural History; as indeed they are in great measure by Pliny, the only person who ever under-

[1] In the *Advancement of Learning*, Bacon had given a quadripartite division of history —natural, civil, ecclesiastical, and literary. The third and fourth he now includes in the second.

[2] The antithesis of nature and art is a celebrated doctrine in the peripatetic philosophy. Natural things are distinguished from artificial, inasmuch as they have, what the latter are without, an intrinsic principle of formation. Aristotle, *De Gen. Anim.* ii. c. 1. The views which Bacon here expresses as to nature and art recur repeatedly in his writings.

[See note on p. 259.]

took a Natural History according to the dignity of it [3]; though he was far from carrying out his undertaking in a manner worthy of the conception.

The first of these, the history of nature in course, is extant, and that in moderate perfection; but the two latter are so weakly and unprofitably handled that they may be set down as deficient. For you will find no sufficient and competent collection of those works of nature which have a digression and deflection from the ordinary course of generations, productions, and motions; whether they be singularities of place and region, or the strange events of time, or *casuum ingenia* (as they have been called)—devices of chance, or the effects of hidden properties, or productions of nature singular in their kind. It is true, I find books more than enough filled with fabulous experiments, idle secrets, and frivolous impostures, for pleasure and novelty; but a substantial and methodical collection of the Heteroclites or Irregulars of nature well examined and described I find not; especially not with due rejection and as it were public proscription of fables and popular errors. For as things now are, if an untruth in nature once get a footing and be made common, what by reason of men's reverence for antiquity, what by reason of the troublesomeness of putting it to the test anew, and what by reason of the use of the opinion in similitudes and ornaments of speech [4], it is never overthrown or retracted.

The end of this work, honoured with a precedent in Aristotle [5], is nothing less than to gratify the appetite of curious and vain wits, as the manner of mirabilaries is to do; but for two reasons, both of great weight; the one to correct the partiality of axioms and opinions, which are framed for the most part upon common and familiar examples; the other, because from the wonders of nature is the most clear and open passage to the wonders of art. For you have but to follow and as it were hound nature in her wanderings, and you will be able, when you like, to lead and drive her afterwards to the same place again. Neither am I of opinion, in this history of marvels, that superstitious narratives of sorceries, witchcrafts, charms, dreams, divinations, and the like, where there is an assurance and clear evidence of the fact, should be altogether excluded. For it is not yet known in what cases, and how far, effects attributed to superstition participate of natural causes; and therefore howsoever the use and practice of such arts is to be condemned, yet from the speculation and consideration of them (if they be diligently unravelled) a useful light may be gained, not only for the true judgment of the offences of persons charged with such practices, but likewise for the further disclosing of the secrets of nature. Neither ought a man to make scruple of entering and penetrating into these holes and corners, when the inquisition of truth is his sole object,—as your Majesty has shown in your own example; who, with the two clear and acute eyes of religion and natural philosophy, have looked deeply and wisely into those shadows, and yet proved yourself to be truly of the nature of the sun, which passes through pollutions and is not defiled [6]. I would recommend however that those narrations which are tinctured with superstition be sorted by themselves, and not mingled with those which are purely and sincerely natural. But as for narrations touching the prodigies and miracles of religions, they are either not true or not natural; and therefore impertinent for the story of nature.

For History of Nature Wrought, or Mechanical, as I also call it, I find some collections made of agriculture and likewise of many manual arts; but always

[3] Of Pliny's *Natural History* Humboldt has remarked that it is a book "which in richness of content no other work of antiquity comes near".—*Kosmos*, ii. 23. Sir T. Browne observes that there is scarcely any vulgar error which is not to be found in it.

[4] In Gilbert's work *De Magnete*, ii. 2, we find an amusing complaint of the same kind. It is worthy of remark that in the account Gilbert has given of the magnetical speculations of earlier writers, almost the only person of whose opinion he speaks with respect is S. Thomas Aquinas, among whose opuscula will be found one on the magnet.

[5] It is generally admitted that the *De Miris Auscultationibus* is not Aristotle's.

[6] The allusion is to King James's *Dæmonologie*, a work in three books, consisting of dialogues between Philomathes and Epistemon; the latter of whom represents the king's opinions on witchcraft.

(which is a great detriment in this kind of learning) with a neglect and rejection of experiments familiar and vulgar; which yet in the interpretation of nature are of equal, if not of more value than those which are less common. For it is esteemed a kind of dishonour upon learning for learned men to descend to inquiry or meditation upon matters mechanical; except they be such as may be thought secrets of art, or rarities and special subtleties. Which humour of vain and supercilious arrogancy is justly derided in Plato, where he brings in Hippias, a vaunting Sophist, disputing with Socrates, a true and unfeigned inquisitor of truth; where, the discourse being touching beauty, Socrates, after his loose and wandering manner of inductions, put first an example of a fair virgin, then of a fair horse, then of a fair pot well glazed. Whereat Hippias was offended, and said, "Were it not for courtesy's sake, I should be loth to dispute with one that did allege such base and sordid instances." Whereunto Socrates answered, "You have reason, and it becomes you well, being a man so trim in your vestments, and so fairly shod"; and so goes on in irony[7]. But the truth is, that they are not the highest instances which give the best or securest information; as is expressed not inelegantly in the common story of the philosopher[8] who, while he gazed upwards to the stars, fell into the water; for if he had looked down he might have seen the stars in the water, but looking aloft he could not see the water in the stars. So it often comes to pass that mean and small things discover great better than great can discover small, and therefore it was well observed by Aristotle, "that the nature of everything is best seen in its smallest portions". For which cause he inquires the nature of a commonwealth first in a family and the simplest conjugations of society—(man and wife, parent and child, master and servant)—which are present in every cottage[9]. Even so likewise the nature of this great city of the world, and the policy thereof, must be first sought in its primary concordances, and smallest portions; as we see that that secret of nature (esteemed one of the great mysteries) of the turning of iron touched with the loadstone towards the north, was found out not in bars of iron but in needles.

But if my judgment be of any weight, the use of History Mechanical is, of all others, the most radical and fundamental towards natural philosophy[10]; such natural philosophy I mean as shall not vanish in the fumes of subtle or sublime speculations, but such as shall be operative to relieve the inconveniences of man's estate. For it will not only be of immediate benefit, by connecting and transferring the observations of one art to the use of others, and thereby discovering new commodities; a result which must needs follow when the experience of different arts shall fall under the observation and consideration of one man's mind; but further, it will give a more true and real illumination concerning the investigation of causes of things and axioms of arts, than has hitherto shone upon mankind. For like as a man's disposition is never well known or proved till he be crossed, nor Proteus ever changed shapes till he was straitened and held fast; so nature exhibits herself more clearly under the trials and vexations of art than when left to herself.

Before I dismiss this part of Natural History (which I call mechanical and experimental) I must add that the body of this kind of history should not be made up from the mechanical arts alone, but also from the operative part of the

[7] See the *Hippias major*. The remark, however, which Hippias makes does not refer to what Socrates has said in his own character, but to what he supposes an imaginary interlocutor to say.

[8] Thales.

[9] *Politica*, i. 1. sub finem.

[10] Accordingly this was one of the first things which the Philosophical College which afterwards became the Royal Society attempted to accomplish. Oldenburg writes to Spinoza in September 1661:—"In our philosophical society we proceed diligently as far as opportunity offers with our experiments and observations, lingering over the compilation of the history of mechanic arts, with the idea that the forms and qualities of things can best be explained from mechanical principles, and that all natural effects can be produced through motion, shape, and consistency, without reference to inexplicable forms or occult qualities, which are but the refuge of ignorance."

liberal sciences, as well as from many other practices which have not as yet grown up into arts; so as to omit nothing which may tend to inform the intellect. And this is the first division of Natural History.

CHAPTER III.

The Second Division of Natural History, according to its Use and End, into Narrative *and* Inductive; *and that the noblest end of Natural History is to minister and be in order for the Foundation of Philosophy; which is the end aimed at in* Induction. *The Division of the History of Generations into the History of the* Heavenly Bodies, *the History of* Meteors, *the History of the* Globe of Earth and Sea, *the History of the* Masses *or* Greater Colleges, *and the History of the* Species *or* Lesser Colleges[1].

NATURAL HISTORY, which is threefold (as I said) in subject, is in use twofold. For it is used either for the sake of the knowledge of the things themselves that are committed to the history, or as the primary matter of philosophy. Now the first kind, which aims either to please by the agreeableness of the narrative or to help by the use of experiments, and is pursued for the sake of such pleasure or such profit, I account as far inferior in importance to that which is the stuff and material of a solid and lawful Induction, and may be called the nursing-mother of philosophy. Accordingly I shall now make a second division of Natural History into Narrative and Inductive; the latter whereof I set down as wanting. But let not any one be dazzled either by the great names of ancient philosophers or the great volumes of modern. For I well know that a natural history is extant, large in its bulk, pleasing in its variety, curious often in its diligence; but yet weed it of fables, antiquities, quotations, idle controversies, philology and ornaments (which are more fitted for table talk and the *noctes* of learned men than for the instauration of philosophy), and it will shrink into a small compass. Certainly it is very different from that kind of history which I have in view. For in the first place there are wanting those two parts of natural history which I have just mentioned, Pretergenerations and Arts, of which I make great account; and next, in the third and remaining part, that of Generations, only one out of five parts is sufficiently handled. For the history of Generations is composed of five subordinate parts. First, a history of the *Celestial Bodies*, exhibiting the actual phenomena simply and apart from theories. Second, a history of *Meteors* (including comets), and what they call the *Regions of the Air*; for there is no history of comets, fiery meteors, winds, rains, storms, and the like, which is of any value. Third, a history of the *Earth and Sea* (considered as integral parts of the universe), mountains, rivers, tides, sands, woods, islands, and the shapes of continents as they lie; in all these, inquiring and observing rather the laws of nature than cosmography. Fourth, a history of the *Common Masses of Matter*, which I call the *Greater Colleges* (commonly called the *Elements*); for I find there are no accounts of fire, air, earth, and water, with their natures, motions, operations, and impressions, such as to form a just body of history. Fifth and last, a history of the *Exquisite Collections of Matter*, which I call the *Lesser Colleges*, but which are generally called *Species*. Now it is only in this last that writers have shown any conspicuous industry; and yet in such sort that they have rather filled it with things superfluous (as figures of animals, plants, and the like), than enriched it with sound and careful observations, which should ever be annexed to natural history. And in a word all the natural history we have, whether in the mode of inquiry or in the matter collected, is quite unfit for the end which I have mentioned, namely, the Foundation of Philosophy. Wherefore I set down Inductive History as wanting. And so much for Natural History.

[1] This chapter is an addition to the *Advancement of Learning*.

CHAPTER IV.

The Division of Civil History into Ecclesiastical, Literary, *and* Civil (*which retains the name of the Genus*) *and that the History of* Literature *is wanting. Precepts for the Construction of it.*

Civil History may rightly be divided into three species. First, *Sacred* or *Ecclesiastical ;* next, that which we call *Civil History* (using the generic name specially) ; lastly, the History of *Learning* and *the Arts.* I will begin with the kind last-mentioned ; for the two former are extant, while the latter—the History of Learning—(without which the history of the world seems to me as the statue of Polyphemus without the eye ; that very feature being left out which most marks the spirit and life of the person), I set down as wanting. Not but I know that in the particular sciences of the jurisconsults, mathematicians, rhetoricians, philosophers, we have some slight mention or some barren narrations about the sects, schools, books, authors, and successions belonging to them ; also that there exist some meagre and unprofitable memoirs of the inventors of arts and usages ; but I say that a complete and universal History of Learning is yet wanting. Of this therefore I will now proceed to set forth the argument, the method of construction, and the use.

The *argument* is no other than to inquire and collect out of the records of all time what particular kinds of learning and arts have flourished in what ages and regions of the world ; their antiquities, their progresses, their migrations (for sciences migrate like nations) over the different parts of the globe ; and again their decays, disappearances, and revivals. The occasion and origin of the invention of each art should likewise be observed ; the manner and system of transmission, and the plan and order of study and practice. To these should be added a history of the sects, and the principal controversies in which learned men have been engaged, the calumnies to which they have been exposed, the praises and honours by which they have been rewarded ; an account of the principal authors, books, schools, successions, academies, societies, colleges, orders,—in a word, everything which relates to the state of learning. Above all things (for this is the ornament and life of Civil History), I wish events to be coupled with their causes. I mean, that an account should be given of the characters of the several regions and peoples ; their natural disposition, whether apt and suited for the study of learning, or unfitted and indifferent to it ; the accidents of the times, whether adverse or propitious to science ; the emulations and infusions of different religions ; the enmity or partiality of laws ; the eminent virtues and services of individual persons in the promotion of learning, and the like. Now all this I would have handled in a historical way, not wasting time, after the manner of critics, in praise and blame, but simply narrating the fact historically, with but slight intermixture of private judgment.

For the *manner* of compiling such a history I particularly advise that the matter and provision of it be not drawn from histories and commentaries alone ; but that the principal books written in each century, or perhaps in shorter periods, proceeding in regular order from the earliest ages, be themselves taken into consultation ; that so (I do not say by a complete perusal, for that would be an endless labour, but) by tasting them here and there, and observing their argument, style, and method, the Literary Spirit of each age may be charmed as it were from the dead.

With regard to the *use* of the work, it is not so much to swell the honour and pomp of learning with a profusion of images ; nor because out of my exceeding love for learning I wish the inquiry, knowledge, and preservation of everything that relates thereto to be pursued even to curiosity ; but chiefly for a purpose more serious and important ; which, in a word, is this : I consider that such a history as I have described would very greatly assist the wisdom and skill of learned men in the use and administration of learning ; that it would exhibit the movements and perturbations, the virtues and vices, which take place no less in intellectual than in civil matters ; and that from the observation of these the best system of government might be derived and established. For the works of St. Ambrose or St. Augustine will not make so wise a bishop or divine as a

diligent examination and study of Ecclesiastical History; and the History of Learning would be of like service to learned men. For everything is subject to chance and error which is not supported by examples and experience. And so much for the History of Learning.

CHAPTER V.

On the Dignity and Difficulty of Civil History.[1]

I COME next to *Civil History*, properly so called, whereof the dignity and authority are pre-eminent among human writings. For to its fidelity are entrusted the examples of our ancestors, the vicissitudes of things, the foundations of civil policy, and the name and reputation of men. But the difficulty is no less than the dignity. For to carry the mind in writing back into the past, and bring it into sympathy with antiquity; diligently to examine, freely and faithfully to report, and by the light of words to place as it were before the eyes, the revolutions of times, the characters of persons, the fluctuations of counsels, the courses and currents of actions, the bottoms of pretences, and the secrets of governments; is a task of great labour and judgment—the rather because in ancient transactions the truth is difficult to ascertain, and in modern it is dangerous to tell. Hence Civil History is beset on all sides with faults; some (and these are the greater part) write only barren and commonplace narratives, a very reproach to history; others hastily and disorderly string together a few particular relations and trifling memoirs; others merely run over the heads of events: others, on the contrary, go into all the minutest particularities, and such as have no relation to the main action; some indulge their imaginations in bold inventions; while others impress on their works the image not so much of their minds as of their passions, ever thinking of their party, but no good witness as to facts; some are always inculcating their favourite political doctrines, and idly interrupting the narrative by going out of the way to display them; others are injudiciously prolix in reporting orations and harangues, and even in relating the actions themselves; so that, among all the writings of men, there is nothing rarer than a true and perfect Civil History. But my present purpose in this division of learning is to mark omissions, and not to censure faults. I will now pursue the divisions of Civil History, and those of the different kinds; for the species will be exhibited more clearly under several heads than under one head curiously traced through all its members.

CHAPTER VI.

The First Division of Civil History into Memorials, Antiquities, *and* Perfect History.

CIVIL HISTORY is of three kinds, not unfitly to be compared with the three kinds of pictures or images. For of pictures and images we see some are unfinished, and wanting the last touch; some are perfect; and some are mutilated and defaced by age. So Civil History (which is a kind of image of events and times) may be divided into three kinds, corresponding to these,—*Memorials*, *Perfect History*, and *Antiquities*. For Memorials are history unfinished, or the first rough drafts of history; and Antiquities are history defaced, or remnants of history which have casually escaped the shipwreck of time.

Memorials, or Preparatory History, are of two sorts, whereof the one may be termed *Commentaries*, the other *Registers*. Commentaries set down a bare continuance and tissue of actions and events without the causes and pretexts, the commencements and occasions, the counsels and orations, and other passages of action. For this is the true nature of a commentary, though Cæsar, in modesty mixed with greatness, chose to apply the name of a commentary to the best history extant. But Registers have a twofold character; for they either contain titles of things and persons in order of time, such as are called Annals and

[1] There is nothing corresponding to this chapter in the *Advancement of Learning*.—*J. S.*

Chronologies ; or collections of public acts, such as edicts of princes, decrees of councils, judicial proceedings, public speeches, letters of state, and the like, without a perfect continuance or contexture of the thread of the narration.

Antiquities, or remnants of histories, are (as was said) like the spars of a shipwreck ; when, though the memory of things be decayed and almost lost, yet acute and industrious persons, by a certain perseverance and scrupulous diligence, contrive out of genealogies, annals, titles, monuments, coins, proper names and styles, etymologies of words, proverbs, traditions, archives and instruments as well public as private, fragments of histories scattered about in books not historical,—contrive, I say, from all these things or some of them, to recover somewhat from the deluge of time ; a work laborious indeed, but agreeable to men, and joined with a kind of reverence ; and well worthy to supersede the fabulous accounts of the origins of nations, and to be substituted for fictions of that kind ; entitled however to the less authority, because in things which few people concern themselves about, the few have it their own way.

In these kinds of Imperfect History I think no deficiency is to be assigned ; for they are things, as it were, imperfectly compounded, and therefore any deficiency in them is but their nature. As for epitomes (which are certainly the corruptions and moths of histories) I would have them banished, whereto likewise most men of sound judgment agree, as being things that have fretted and corroded the bodies of many most excellent histories, and wrought them into base and unprofitable dregs.[1]

CHAPTER VII.

The Division of Perfect History into Chronicles, Lives, *and* Relations ; *and the Explanation thereof.*

But *Perfect History* is of three kinds, according to the object which it propounds for representation. For it either represents a portion of time, or a person worthy of mention, or an action or exploit of the nobler sort. The first we call Chronicles or Annals ; the second, Lives ; the third, Narrations or Relations. Of these the first excels in estimation and glory ; the second, in profit and examples ; and the third in verity and sincerity. For History of Times represents the magnitude of public actions, and the public faces and deportments of persons, but omits and covers up in silence the smaller passages and motions of men and matters. But such being the workmanship of God, that he hangs the greatest weights upon the smallest wires, it comes commonly to pass that such a history, pursuing the greater things alone, rather sets forth the pomp and solemnity of business than the true and inward springs and resorts thereof. Moreover, when it does add and insert the counsels and motives, yet from its love of grandeur it introduces into human actions more gravity and prudence than they really have ; so that a truer picture of human life may be found in a satire than in some histories of this kind. Whereas Lives, if they be well and carefully written (for I do not speak of elegies and barren commemorations of that sort), propounding to themselves a single person as their subject, in whom actions both trifling and important, great and small, public and private, must needs be united and mingled, certainly contain a more lively and faithful representation of things, and one which you may more safely and happily take for example in another case. But special Narrations and Relations of actions (as the Peloponnesian War, the Expedition of Cyrus, the Conspiracy of Catiline, and the like) cannot but be more purely and exactly true than the Perfect Histories of Times ; because they may choose a manageable and definite argument, whereof a perfect knowledge and certainty and full information may be had ; whereas the story of a time (especially if it be of a period much before the age of the writer) is sure to meet with many gaps in the records, and to contain empty spaces which must be filled up and supplied at pleasure by wit and conjecture. But this which I say touching the sincerity

[1] Bacon often condemns, and not altogether unjustly, the use of epitomes. The development of a liking for abridgments is certainly a remarkable feature in the decline of Roman literature.

of Relations, must be taken with reservation ; for (seeing that everything human is subject to imperfection, and good is almost always associated with evil) it must certainly be confessed that relations of this kind, especially if published near the time of the actions themselves (being commonly written either in favour or in spite), are of all other histories the most to be suspected. But then again the evil carries this remedy along with it ; that as these very relations are commonly put forth not by one side only, but by both, according to their several factions and parties, a way may be found to truth between the extremes on either hand ; and after party heat has cooled down, a good and prudent historian will obtain from them no bad materials and provision for a more perfect history.

With regard to the deficiencies of these three kinds of history, it is certain that there are many particular histories (I speak of such as may be of some moderate worth and dignity) which have been hitherto neglected, with the greatest detriment to the honour and name of the kings and states to which they belong ; though to mention them would take too much time. But leaving the care of foreign stories to foreign states (for I will not be a meddler in other nations' matters), I cannot fail to represent to your Majesty the unworthiness of the history of England as we now have it, in the main continuance thereof, and the partiality and obliquity of that of Scotland, in the latest and largest author that I have seen [1] ; supposing that it would be honour for your Majesty, and a work very acceptable to future ages, if this island of Great Britain, as it is now joined in one monarchy for the ages to come, so were joined in one history for the ages past ; after the manner of the Sacred History, which draws down the story of the ten tribes and of the two tribes as twins together. And if it shall seem that the greatness of this work (and great and difficult it is) may prevent it from being exactly and worthily performed, there is a memorable period of a much smaller compass of time, as to the history of England ; that is to say, from the Union of the Roses to the Union of the Kingdoms ; a portion of time wherein to my understanding there has been a greater variety of strange events than in like number of successions of any hereditary monarchy has ever been known. For it begins with the mixed obtaining of a crown, partly by arms, partly by title ; an entry by battle, an establishment by marriage ; and therefore times corresponding to these beginnings, like waters after a tempest, full of working and swelling, though without extremity of storm ; but well passed through by the wisdom of the pilot [2], who was the most conspicuous for policy of all the kings who preceded him. Then follows the reign of a king whose actions, though conducted more by impulse than policy, exercised no slight influence over the affairs of Europe ; balancing and inclining them variably. In whose reign also begun that great alteration in the State Ecclesiastical, an action which seldom comes upon the stage. Then the reign of a minor. Then an attempt at a usurpation, though it was but as a diary ague. Then the reign of a queen matched with a foreigner ; then of a queen that lived solitary and unmarried. And now, last, this most happy and glorious event, that this island of Britain, divided from all the world, should be united in itself, and that old oracle given to Æneas (Antiquam exquirite matrem [3]), which foreshowed the rest in store for him, should now be performed and fulfilled upon the most renowned nations of England and Scotland ; being now reunited in the ancient mother name of Britain, as a pledge and token of the end and period of all instability and peregrinations ; so that as it comes to pass in massive bodies, that they have certain trepidations and waverings before they fix and settle ; so it seems to have been ordained by the providence of God that this monarchy, before it settled and was confirmed in your Majesty and your royal generations (in which I hope it is now established for ever), should undergo these prelusive changes and varieties.

For Lives, I find it strange, when I think of it, that these our times have so

[1] Bacon alludes to Buchanan, of whom James speaks with much bitterness in the *Basilicon Doron*. It has been said that Buchanan's mind was failing when he wrote the concluding books of his history, in which Mary Queen of Scots is so much vilified.

[2] [Henry VII.]

[3] Seek out your ancient mother. Virg. *Æn.* iii. 96.

little esteemed their own virtues, as that the commemoration and writings of the lives of those who have adorned our age should be no more frequent. For although there be but few sovereign kings or absolute commanders, and not many princes in free states (so many free states being now turned into monarchies), yet are there many worthy personages (even living under kings) that deserve better than dispersed report or dry and barren eulogy. For herein the invention of one of the later poets, by which he has enriched the ancient fiction, is not inelegant. He feigns that at the end of the thread or web of every man's life there hangs a little medal or collar, on which his name is stamped; and that Time waits upon the shears of Atropos, and as soon as the thread is cut, snatches the medals, carries them off, and presently throws them into the river Lethe; and about the river there are many birds flying up and down, who catch the medals, and after carrying them round and round in their beak a little while, let them fall into the river; only there are a few swans, which if they get a medal with a name immediately carry it off to a temple consecrated to immortality [4]. Now this kind of swan is for the most part wanting in our age. And although there are many men, more mortal in their cares and desires than in their bodies, who regard the desire of name and memory but as a vanity and ventosity,

Animi nil magnæ laudis egentes; [5]

whose philosophy and severity springs no doubt from that root "Non prius laudes contempsimus, quam laudanda facere desivimus [6]"—yet that will not alter Solomon's judgment. "The memory of the just is praised, but the name of the wicked shall rot [7]". The one flourishes for ever; the other either consumes to present oblivion, or turns to an ill odour. And therefore in that style or form of words which is well appropriated to the dead—(of happy memory, of pious memory, of blessed memory),—we seem to acknowledge that which Cicero says (having borrowed it from Demosthenes), "That good fame is the only possession a dead man has [8]"; which possession I cannot but note that in our times it lies in most part waste and neglected.

For *Narrations* and *Relations*, a greater diligence therein is also much to be wished; for there is hardly any great action which is not attended by some good pen that can describe it. And because it is an ability not common to write a perfect history as it ought to be written (as may well appear from the small number even of moderate historians), yet if particular actions were but tolerably reported as they pass, it might be expected that a writer would some time or other arise who by such help and assistance might compile a complete History of Times. For the collection of such Relations would be as a nursery, whereby to plant a fair and stately garden when time should serve.

CHAPTER VIII [1].

The Division of the History of Times into History Universal and Particular—*their Advantages and Disadvantages.*

HISTORY of Times is either Universal or Particular; whereof the latter contains the deeds of some kingdom, commonwealth, or people; the former those of the

[4] The poet referred to is Ariosto, *Orlando Furioso*, at the end of the 34th and beginning of the 35th Books. For this reference I am indebted to Mr. Singer, *Notes and Queries*, vol. v. p. 232. He remarks that the *Orlando Furioso* was then popular in the recent translation of Sir John Harrington. It would seem as if Bacon refers to the translation, which ascribes the power of giving immortality to "*Historians* learned and Poets rare," whereas the original speaks only of poets.

[5] "Souls that care not for praise."—Virg. *Æn.* v. 751.

[6] "When we have ceased to do things deserving of praise we find that praise is an idle thing."—*Plin. Ep.* iii. 91.

[7] Prov. x. 7.

[8] Cf. Cicero, *Philipp.* ix., and Demos. Λογ. επιταφ. 1389, 10.

[1] There is nothing corresponding to this chapter in the *Advancement of Learning*.—*J. S.*

whole world. For there have been those who have affected to write the history of the world from its very beginning; exhibiting by way of history a medley of things and abridgments of narratives. Others have attempted to comprise, as in a perfect history, the memorable events of their own age all over the world; with noble enterprise, and no small result. For the affairs of men are not so far separated by the divisions of empires or countries, but they have a connexion in many things; and therefore it is certainly of use to have the fates, acts, and destinies of one age described and contained as it were on one tablet. It is true also that many writings of no contemptible character (such as are those Relations of which I previously spoke), which would otherwise perish and not be reprinted,—that these, or at all events the principal matters in them, find a place in a general history of this kind, and in this way are fixed and preserved. But if due attention be paid to the subject, it will be found that the laws of regular history are so strict, that they can scarce be observed in such a wide field of matter; so that the dignity of history is rather diminished than increased by the greatness of the mass of it. For the writer who has such a variety of things on all sides to attend to, will become gradually less scrupulous on the point of information; his diligence, grasping at so many subjects, will slacken in each; he will take up with rumours and popular reports, and thus construct his history from relations which are not authentic, or other frivolous materials of the kind. He will be obliged moreover (lest the work increase beyond measure) purposely to omit a number of things worthy of record, and often to sink into abridgments. He is liable likewise to another danger, not small, and diametrically opposed to the very utility which belongs to Universal History; for as Universal History preserves some narrations which would perhaps otherwise perish, so on the other hand it destroys many that are profitable enough in themselves and would otherwise live, for the sake of that compendious brevity of which men are so fond.

CHAPTER IX.

Another Division of the History of Times into Annals *and* Journals.

The History of Times is also rightly divided into *Annals* and *Journals;* which division, though it take its name from periods of time, yet has also reference to the choice of subjects. For it is well observed by Cornelius Tacitus, after touching upon the magnificence of certain buildings, "That it was found suitable to the dignity of the Roman people to commit to Annals only matters of note, but such things as these to the Journals of the City" [1]; thus referring matters concerning the state to Annals, but the less important kind of actions or accidents to Journals. Certainly, in my judgment, there ought to be a kind of heraldry in arranging the precedence of books, no less than of persons. For as nothing derogates from the dignity of a state more than confusion of ranks and degrees, so it not a little embases the authority of a history to intermingle matters of lighter moment, such as triumphs, ceremonies, spectacles, and the like, with matters of state. And surely it were to be wished that this distinction came into fashion. But in our times journals are only used in sea-voyages and expeditions of war; whereas in ancient times it was a matter of honour with princes to keep journals of what passed day by day in their courts; as we see in the case of Ahasuerus, King of Persia, who, when he could not take rest, called for the Chronicles, where he read over again the account of the conspiracy of the Eunuchs [2]. But the journals of Alexander's house expressed every small particularity, so that even if he happened to sleep at table it was registered [3]. Not that, as none but grave matters were included in the Annals, so none but trifling ones were admitted into Journals; but everything, whether of greater or less concern, was promiscuously entered in the Journals as it passed.

[1] Tac. Ann. xiii. 31. [2] Esther, vi. 1. [3] Plut. Symp. i. 6.

CHAPTER X.

The Second Division of Civil History into Pure *and* Mixed.

THE last division of Civil History is into *Pure* and *Mixed*. Of the Mixed there are two principal kinds; the one taken from Civil Science, the other principally from Natural. For some men have introduced a form of writing consisting of certain narratives not woven into a continuous history, but separate and selected according to the pleasure of the author; which he afterwards reviews, and as it were ruminates over, and takes occasion from them to make politic discourse and observation [1]. Now this kind of Ruminated History I greatly approve, provided that the writer keep to it and profess it. But for a man who is professedly writing a Perfect History to be everywhere introducing political reflexions, and thereby interrupting the narrative, is unseasonable and wearisome. For though every wise history is pregnant (as it were) with political precepts and warnings, yet the writer himself should not play the midwife.

Another kind of Mixed History is the History of Cosmography; which is indeed mixed of many things; of Natural History, in respect of the regions themselves, their sites and products; of History Civil, in respect of the habitations, governments, and manners of the people; and of Mathematics, in respect of the climates and configurations of the heavens, beneath which the regions of the world lie. In which kind of history or science we may congratulate our own age. For this great building of the world has in our age been wonderfully opened and thorough-lighted; and though the ancients had knowledge of the zones and the antipodes,

> Nosque ubi primus equis oriens afflavit anhelis,
> Illic sera rubens accendit lumina Vesper [2],

yet that might be by demonstration rather than by travel. But for a little vessel to emulate the heaven itself, and to circle the whole earth with a course even more oblique and winding than that of the heavenly bodies, is the privilege of our age; so that these times may justly bear in their motto not only *plus ultra* [3]—further yet—in precedence of the ancient *non ultra*—no further; and "Imitable Thunder" in precedence of the ancient "Inimitable Thunder",

> (Demens qui nimbos, et non imitabile fulmen, etc.) [4],

but likewise, that which exceeds all admiration, "Imitable Heaven," in respect of our sea-voyages, by which the whole globe of earth has, after the manner of the heavenly bodies, been many times compassed and circumnavigated.

And this proficience in navigation and discovery may plant also great expectation of the further proficience and augmentation of the sciences; especially as it may seem that these two are ordained by God to be coevals, that is, to meet in one age. For so the Prophet Daniel, in speaking of the latter times, foretells "That many shall go to and fro on the earth, and knowledge shall be increased" [5], as if the opening and thorough passage of the world, and the increase of knowledge, were appointed to be in the same age; as we see it is already performed in great part; the learning of these our times, not much giving place to the two former periods or returns of learning (the one of the Grecians, the other of the Romans), but in some respects far exceeding them.

[1] The most celebrated work of this kind is one with which Bacon was familiar,—the *Discorsi* of Machiavelli, of which the narrative part is derived from Livy. Ammirati, who died in 1600, took Tacitus as his author. His *Discorsi* never attained the celebrity of those of Machiavelli.

[2] And while on us the early morning breathes
With panting horses, there the blushing eve
Lights up her tardy signals.—Virgil, *Georg.* i. 250.

[3] "*Plus ultra*," which Bacon often quotes, was the motto adopted by the emperor Charles V.

[4] Virg. *Æn.* vi. 590.

[5] Daniel, xii. 4.

CHAPTER XI.

The Division of Ecclesiastical History into Ecclesiastical History Special, History of Prophecy, *and* History of Providence.

History Ecclesiastical receives nearly the same divisions as History Civil, for there are Ecclesiastical Chronicles, there are Lives of the Fathers, there are Relations of Synods and other things pertaining to the Church. But in itself it is properly divided into *History Ecclesiastical* (using the general name in a special sense), *History of Prophecy*, and *History of Divine Judgments or Providence*. The first describes the times of the Church Militant, and its different states; whether fluctuant, as the ark of Noah; or moveable, as the ark in the wilderness; or at rest, as the ark in the Temple; that is, the state of the Church in persecution, in remove, and in peace. In this part I find no deficiency, but rather superfluities; only I would that the virtue and sincerity of the relations were in accordance with the mass and quantity of the matter.

The second, which is History of Prophecy, consists of two relatives, the Prophecy and the Accomplishment; and therefore the plan of such a work ought to be, that every prophecy of Scripture be sorted with the event fulfilling the same, throughout all ages of the world; both for the better confirmation of faith, and for better instruction and skill in the interpretation of those parts of prophecies which are yet unfulfilled; allowing nevertheless that latitude which is agreeable and familiar to divine prophecies, that the fulfilments of them are taking place continually and not at the particular time only. For they are of the nature of their Author, "to whom a thousand years are but as one day, and one day as a thousand years" [1]; and though the height or fulness of them is commonly referred to some one age or particular period, yet they have at the same time certain gradations and processes of accomplishment through divers ages of the world. This is a work which I find deficient, but it is one that is to be done with great wisdom, sobriety, and reverence, or not at all.

The third part, which is History of Providence, has indeed been handled by the pens of some pious writers, but not without partiality. Its business is to observe that divine correspondence which sometimes exists between God's revealed and secret will. For though the judgments and counsels of God are so obscure that to the natural man they are altogether inscrutable, yea, and many times hidden from the eyes of those that behold them from the tabernacle, yet at some time it pleases the Divine Wisdom, for the better establishment of His people, and the confusion of those who are as without God in the world, to write it and report it to view in such capital letters that (as the Prophet saith) "He that runneth by may read it" [2]; that is, that mere sensual persons and voluptuaries, who hasten by God's judgments, and never bend or fix their thoughts upon them, are nevertheless, though running fast and busy about other things, forced to discern them. Such are late and unlooked for judgments; deliverances suddenly and unexpectedly vouchsafed; divine counsels, through tortuous labyrinths and by vast circuits, at length manifestly accomplishing themselves; and the like; all which things serve not only to console the minds of the faithful, but to strike and convince the consciences of the wicked.

[1] Psalm xc. 4., and 2 Pet. iii. 8.

[2] Habakkuk, ii. 2. Bacon seems to have misunderstood the meaning of the passage, the English translation of which is quite in accordance both with the Vulgate and with the Septuagint version. The meaning may be thus paraphrased: "Write so as that the message may be quickly read, in order that the reader may run at once and without loss of time". The idea of quick reading seems to have suggested that of a hasty and careless reader.

In my copy of Acosta's sermons for Advent, which has Bacon's autograph on the flyleaf, and for which I am indebted to the kindness of the Rev. P. La Trobe, the following words are underlined: "Sed explanari in tabulis visio prophetica jubetur, ut possit, celeriter a legente percipi."—*Acostæ Conciones de Adventu*, (Col. Agrip. 1609) p. 178. Bacon perhaps connected *celeriter* with *legente* instead of with *percipi*, and was thus led to suppose that the passage was to be understood in the way in which he has taken it.

CHAPTER XII.

Of the Appendices to History ; which deal with the Words of Men (as History itself deals with their Actions). The Division thereof into Orations, Letters, *and* Apophthegms.

But not only man's *actions*, but his *words* also should be recorded. And these are no doubt sometimes inserted in history itself, so far as they contribute to the perspicuity and weight of the narrative. But the saying or words of men are properly preserved in books of *Speeches*, *Letters*, and *Apophthegms*. Certainly the Speeches of wise men on business and matters of grave and deep importance conduce greatly as well to the knowledge of the things themselves as to eloquence. But for instruction in civil prudence, still greater help is derived from Letters written by great men on weighty subjects. For of all the words of man nothing is more solid and excellent than letters of this kind ; for they are more natural than orations, and more advised than conferences on the sudden. And when there is a continued series of them in order of time (as we find in the letters of ambassadors, governors of provinces, and other ministers of state, to kings, senates, and other superior officers ; or, again, in the letters of rulers to their agents), they are of all others the most valuable materials for history. Neither are Apophthegms themselves only for pleasure and ornament, but also for use and action. For they are (as was said) " words which are as goads ",[1] words with an edge or point, that cut and penetrate the knots of business and affairs. Now occasions are continually returning, and what served once will serve again ; whether produced as a man's own or cited as an old saying. Nor can there be any question of the utility in civil matters of that which Cæsar himself thought worthy of his labour ; whose book of Apophthegms I wish were extant ; for all the collections which we have of this kind appear to me to have been compiled without much judgment.

And so much concerning History ; which is that part of learning which answers to one of the cells, domiciles, or offices of the mind of man, which is that of the Memory.

CHAPTER XIII.

On the second principal part of Learning, namely, Poesy. The Division of Poesy into Narrative, Dramatic, *and* Parabolical. *Three Examples of Parabolical Poesy are propounded.*

I now come to Poesy, which is a part of learning in measure of words for the most part restrained, but in all other points extremely free and licensed ; and therefore (as I said at first) it is referred to the imagination, which may at pleasure make unlawful matches and divorces of things. Now Poesy, as I have already observed, is taken in two senses ; in respect of words or matter. In the first sense it is but a character of speech ; for verse is only a kind of style and a certain form of elocution, and has nothing to do with the matter ; for both true history may be written in verse and feigned history in prose. But in the latter sense, I have set it down from the first as one of the principal branches of learning, and placed it by the side of history ; being indeed nothing else but an imitation of history at pleasure. And therefore, endeavouring as I do in these divisions to trace out and pursue the true veins of learning, without (in many points) following customs and the divisions which are received, I dismiss from the present discourse Satires, Elegies, Epigrams, Odes, and the like ; and refer them to philosophy and arts of speech. And under the name of Poesy, I treat only of feigned history.

The division of Poesy which is aptest and most according to the propriety thereof, besides those divisions which it has in common with History (for there are feigned Chronicles, feigned Lives, and feigned Relations), is into Poesy *Narrative*, *Dramatic*, and *Parabolical*. Narrative Poesy is a mere imitation of History, such as might pass for real, only that it commonly exaggerates things beyond probability. Dramatic Poesy is as History made visible ; for it represents ac-

[1] [Orig. *Secures aut mucrones verborum.* Cicero, *Epist. Fam.* ix.]

tions as if they were present, whereas History represents them as past. Parabolical Poesy is typical History, by which ideas that are objects of the intellect are represented in forms that are objects of the sense.

As for Narrative Poesy,—or Heroical, if you like so to call it (understanding it of the matter, not of the verse)—the foundation of it is truly noble, and has a special relation to the dignity of human nature. For as the sensible world is inferior in dignity to the rational soul, Poesy seems to bestow upon human nature those things which history denies to it ; and to satisfy the mind with the shadows of things when the substance cannot be obtained. For if the matter be attentively considered, a sound argument may be drawn from Poesy, to show that there is agreeable to the spirit of man a more ample greatness, a more perfect order, and a more beautiful variety than it can anywhere (since the Fall) find in nature. And therefore, since the acts and events which are the subjects of real history are not of sufficient grandeur to satisfy the human mind, Poesy is at hand to feign acts more heroical ; since the successes and issues of actions as related in true history are far from being agreeable to the merits of virtue and vice, Poesy corrects it, exhibiting events and fortunes as according to merit and the law of providence ; since true history wearies the mind with satiety of ordinary events, one like another, Poesy refreshes it, by reciting things unexpected and various and full of vicissitudes. So that this Poesy conduces not only to delight but also to magnanimity and morality. Whence it may be fairly thought to partake somewhat of a divine nature ; because it raises the mind and carries it aloft, accommodating the shows of things to the desires of the mind, not (like reason and history) buckling and bowing down the mind to the nature of things. And by these charms, and that agreeable congruity which it has with man's nature, accompanied also with music, to gain more sweet access, it has so won its way as to have been held in honour even in the rudest ages and among barbarous peoples, when other kinds of learning were utterly excluded.

Dramatic Poesy, which has the theatre for its world, would be of excellent use if well directed. For the stage is capable of no small influence both of discipline and of corruption. Now of corruptions in this kind we have enough ; but the discipline has in our times been plainly neglected. And though in modern states play-acting is esteemed but as a toy, except when it is too satirical and biting ; yet among the ancients it was used as a means of educating men's minds to virtue. Nay, it has been regarded by learned men and great philosophers as a kind of musician's bow by which men's minds may be played upon. And certainly it is most true, and one of the great secrets of nature, that the minds of men are more open to impressions and affections when many are gathered together than when they are alone [1].

[1] There is nothing in the *Advancement of Learning* corresponding to this paragraph. It is a curious fact that these remarks on the character of the modern drama were probably written, and were certainly first published, in the same year which saw the first collection of Shakespeare's plays ; of which, though they had been filling the theatre for the last thirty years, I very much doubt whether Bacon had ever heard. How little notice they attracted in those days as works of literary pretension, may be inferred from the extreme difficulty which modern editors have found in ascertaining the dates, or even the order, of their production. Though numbers of contemporary news-letters, filled with literary and fashionable intelligence, have been preserved, it is only in the Stationer's register and the accounts kept by the Master of the Revels that we find any notices of the publication or acting of Shakespeare's plays. In the long series of letters from John Chamberlain to Dudley Carleton, scattered over the whole period from 1598 to 1623,—letters full of the news of the month ; news of the court, the city, the pulpit, and the bookseller's shop ; in which court-masques are described in minute detail, author, actors, plot, performance, reception and all ;—we look in vain for the name of Shakespeare or of any one of his plays. And yet during that period Hamlet, Twelfth Night, Othello, Measure for Measure, the Merchant of Venice, Macbeth, Lear, The Tempest, the Winter's Tale, Coriolanus, and several more, must have appeared as novelties. And indeed that very letter without which we should hardly know that Shakespeare was personally known to any one in the great world as a distinguished dramatic writer,

But Parabolical Poesy is of a higher character than the others, and appears to be something sacred and venerable ; especially as religion itself commonly uses its aid as a means of communication between divinity and humanity. But this too is corrupted by the levity and idleness of wits in dealing with allegory. It is of double use and serves for contrary purposes ; for it serves for an infoldment ; and it likewise serves for illustration. In the latter case the object is a certain method of teaching, in the former an artifice for concealment. Now this method of teaching, used for illustration, was very much in use in the ancient times. For the inventions and conclusions of human reason (even those that are now common and trite) being then new and strange, the minds of men were hardly subtle enough to conceive them, unless they were brought nearer to the sense by this kind of resemblances and examples. And hence the ancient times are full of all kinds of fables, parables, enigmas, and similitudes ; as may appear by the numbers of Pythagoras, the enigmas of the Sphinx, the fables of Æsop, and the like. The Apophthegms too of the ancient sages commonly explained the matter by similitudes. Thus Menenius Agrippa among the Romans (a nation at that time by no means learned) quelled a sedition by a fable. In a word, as hieroglyphics were before letters, so parables were before arguments. And even now, and at all times, the force of parables is and has been excellent ; because arguments cannot be made so perspicuous nor true examples so apt.

But there remains yet another use of Poesy Parabolical, opposite to the former ; wherein it serves (as I said) for an infoldment ; for such things, I mean, the dignity whereof requires that they should be seen as it were through a veil ; that is when the secrets and mysteries of religion, policy, and philosophy are involved in fables or parables. Now whether any mystic meaning be concealed beneath the fables of the ancient poets is a matter of some doubt. For my own part I must confess that I am inclined to think that a mystery is involved in no small number of them [2]. Nor does the fact that they are left commonly to boys and grammarians, and held in slight repute, make me despise them ; but rather, since it is evident that the writings in which these fables are related are, next to sacred story, the most ancient of human writings, and the fables themselves still more ancient (for they are related not as being invented by the writers, but as things believed and received from of old), I take them to be a kind of breath from the traditions of more ancient nations, which fell into the pipes of the Greeks. But since that which has hitherto been done in the interpretation of these parables, being the work of unskilful men, not learned beyond commonplaces, does not by any means satisfy me, I think fit to set down Philosophy according to the Ancient

—I mean Lord Southampton's letter in furtherance of a petition from him and Burbage to the Lord Chancellor Ellesmere—proves at the same time how little was known about him by people of that quality. "This other" (he writes, after describing him as his especial friend and the writer of some of our best English plays,) hath to name William Shakespeare. . . . Both are right famous in their qualities, though it longeth not of your lordship's gravity and wisdom to resort unto the places where they were wont to delight the public ear." This was in 1608 ; and yet only six years before, when Ellesmere received Elizabeth at Harewood, Othello had been acted there for her entertainment. Even now a writer otherwise unknown hardly becomes known as the author of a successful play. "At present," said Mr. Rogers, "new plays seem hardly to be regarded as literature ; people may go to see them acted, but no one thinks of reading them. During the run of *Paul Pry*, I happened to be at a dinner-party, where everybody was talking about it,—that is, about Liston's performance of the hero. I asked first one person, then another, and then another, who was the author of it ? Not a man or woman in the company knew that it was written by Poole ! "—*Recollections of the Table-talk of Samuel Rogers*, p. 253.—*J. S.*

[2] The hesitating manner in which Bacon here expresses himself shows that he felt, what every one in modern times who has considered the subject must I think feel, how difficult it is to enter into the spirit of the ancient mythus. Its essence seems to consist in a half-conscious blending of an idea with something that was accepted as a fact. See particularly on this point Müller's *Introduction to Mythology*. The mythus degenerates into allegory when the idea and the fact are conceived of as antithetical.

Parables among the *desiderata*. Of which work I will subjoin one or two examples; not so much perhaps for the value of the thing as for the sake of carrying out my principle; which is this; whenever I set down a work among the desiderata (if there be anything obscure about it), I intend always to set forth either instructions for the execution of it, or an example of the thing; else it might be thought that it was merely some light notion that had glanced through my mind; or that I am like an augur measuring countries in thought, without knowing the way to enter them. I can report no other deficiency in Poesy; for being as a plant which comes from the lust of the earth without a formal seed, it has sprung up and spread abroad more than any other kind of learning. But I will now propound the examples, only three in number; one taken from things Natural, one from things Political, and one from things Moral.

The First Example of Philosophy according to the Fables of the Ancients, in Natural Philosophy. Of the Universe, *according to the Fable of* Pan.

The ancients leave the parentage of Pan uncertain. Some call him the son of Mercury; others attribute to him a very different mode of generation, affirming that he sprang from the promiscuous intercourse of Penelope with all the suitors. There is also a third account, which must not be omitted; for some have declared that he was the son of Jupiter and Hybris (which signifies Contumely). Whatever his origin, the Fates are said to have been his sisters; who dwelt in a cave underground; while he himself lived in the open air. The person of Pan is described by ancient tradition as follows:—horns on his head, rising to a point and reaching up to heaven; his whole body rough and shaggy; his beard especially long; his figure biform, the upper part human, the lower part like a beast and ending in goat's feet. He carried as insignia of his office, in his left hand a pipe compact of seven reeds, in his right a shepherd's crook or staff, curved and bent at the upper end. His dress was a mantle of leopard's skin. The titles and offices attributed to him were these; he was the god of hunters; also of shepherds, and of all persons dwelling in the country; the president likewise of mountains. He was moreover next to Mercury the messenger of the Gods. He was regarded as the leader and commander of the Nymphs, who were always wont to dance and frisk around him. The Satyrs and their elders the Sileni were also of his company. He had besides the power to inspire sudden terrors, such especially as were vain and superstitious, which received the name of *Panics*. Not many actions are recorded of him. The chief one is that he challenged Cupid at wrestling and was overcome in the contest. He also caught the giant Typhon in nets and held him fast. They say likewise that when Ceres, in sorrow and passion for the rape of Proserpine, had hid herself, and all the gods were eagerly engaged in seeking her, and had dispersed themselves in different paths for the pursuit, it was reserved for Pan to meet with her by a happy accident as he was hunting, and inform the rest of her hiding-place. He presumed also to contend in music with Apollo, and in the judgment of Midas was pronounced victor; for which judgment Midas had to wear the ears of an ass, but not so as to be seen. No amours, or at least very few, are related of Pan; a strange thing for one of a crowd of Gods so profusely amorous. It is only said of him that he was the lover of Echo, who was also esteemed his wife; and of one other nymph besides, named Syringa; with desire for whom he was inflamed by the revengeful anger of Cupid, whom he had not scrupled to challenge to the wrestling. He is also said on one occasion to have drawn the Moon apart into deep woods. Moreover he had no issue (which likewise is a marvel, when the gods, especially those of the male kind, were so prolific), unless it were one daughter, a little handmaid named Iambe, who used to amuse strangers with ridiculous stories; and was supposed by some to be Pan's daughter by his wife Echo. The parable may be thus explained.

Pan (as the name itself imports) represents and denotes the Universe, or the All of Things. Concerning his origin there are only two opinions, nor can there indeed be more. For he either sprang from Mercury, that is, the Word of God (which the Holy Scripture places beyond question, and which was perceived also

by those of the philosophers themselves who have been accounted most divine), or else from the seeds of things mixed and confused together. For some philosophers have set down the seeds of things as infinite in their substance; whence arose the doctrine of *Homœomeræ*, which Anaxagoras either invented or brought into repute. Some with greater penetration and judgment thought that the variety of things would be sufficiently explained, if the seeds were supposed to be in substance the same, but to take various, though certain and definite, figures; accounting for the rest by the position and connexion of the seeds one with the other [3]; from which opinion emanated the doctrine of Atoms invented by Leucippus, and sedulously followed out by Democritus. Others, though they asserted one principle of things (as Thales, Water; Anaximenes, Air; Heraclitus, Fire), yet maintained that principle itself to be actually one, but potentially [4] various and dispensable, as that which had latent within it the seeds of all things. But those who (like Plato and Aristotle) have represented Matter as entirely despoiled, shapeless, and indifferent to forms, have approached much nearer to the figure of the parable. For they have made Matter as a common harlot, and Forms as suitors [5]; so that all the opinions about the origins of things return to this point, and may be reduced to this distribution,—that the universe proceeds either from Mercury, or from Penelope and all her suitors. From the third story of Pan's origin, it would seem as if the Greeks, either by intercourse with the Egyptians or otherwise, had heard something of the Hebrew mysteries. For it relates to the state of the world, not at its very birth, but after the fall of Adam; exposed and made subject to death and corruption. For that state was and is the offspring of God and Sin (or Contumely). For the sin of Adam, when he wished to "become like God", was a kind of contumely. Therefore the threefold account of the birth of Pan may be allowed as true, if rightly distinguished with respect to facts and times. For this Pan (as we now view and understand him) is the offspring of the *Divine Word*, through the medium of *confused matter* (which itself however was the work of God), and with the help of *Sin*, and by Sin Corruption, entering in.

To the Nature of things, the *Fates* or Destinies of things are truly represented as sisters. For the beginnings, durations, and ends of things, as also their fallings, risings, labours, felicities, and in a word whatever may happen to an individual, are termed Fates; which, however, except it be in some noble individual (as a man, or a city, or a people), are commonly not observed and recognised. Now it is *Pan*, that is, the nature of things, that reduces these separate individuals to such various conditions; insomuch that the chain of nature and the thread of the Fates are (so far as individuals are concerned) the same thing. In addition to this the ancients feigned that Pan lived always in the open air, but the Fates in a huge subterranean cave, whence they suddenly flew to men with exceeding swiftness; because nature and the face of the universe is open and visible, whereas the fates of individuals are secret and rapid. But if Fate be taken in a wider acceptation, so as to signify every event of any kind, and not the more noble only, yet in this sense too it excellently answers to the universal frame of things; seeing that there is nothing in the order of nature so small as to be without a cause, nor again anything so great but it depends on something else; so that the fabric of nature contains in her own lap and bosom every event whatever, both small and great, and developes them in due season by a fixed law. Therefore no wonder that the Parcæ are represented as sisters of Pan, and certainly legitimate. For Fortune is the child of the vulgar, and has only found favour with the lighter kind of philosophers. Indeed Epicurus seems not only to be profane, but also foolish, when he says "That it is better to believe in the fable of the gods, than to

[3] To this opinion Bacon himself doubtless inclined, but he was not I think a believer in any atomic theory; that is to say, he seems to have rejected the idea of a vacuum. Of Democritus, however, so far as relates to his physical theories, he always speaks with respect. Leibnitz has remarked that the view which Bacon here mentions is common to all the scientific reformers of the early part of the seventeenth century.

[4] The antithesis of the actual and the potential is a fundamental doctrine in the peripatetic philosophy.

[5] See Arist. Physics, i. c. 9.

assert the power of fate "[6]; as if anything in the universe could be like an island, separated from connexion with the rest. But Epicurus, accommodating and subjecting his natural to his moral philosophy (as appears from his own words), would not willingly admit any opinion that depressed or hurt the mind, and troubled or disturbed that *Euthumia* of his, which he had adopted from Democritus. And so being more fond of enjoying the sweets of thought than patient of the truth, he fairly threw off the yoke, and rejected both the necessity of Fate and the fear of the gods. And so much for the relationship of Pan to the Fates.

Horns are attributed to the Universe, broad at the base and pointed at the top. For all nature rises to a point like a pyramid. Individuals, which lie at the base of nature, are infinite in number; these are collected into Species, which are themselves manifold; the Species rise again into Genera; which also by continual gradations are contracted into more universal generalities, so that at last nature seems to end as it were in unity; as is signified by the pyramidal form of the horns of Pan. Nor need we wonder if the horns of Pan reach even to the heaven, seeing that the transcendentals of nature, or universal ideas, do in a manner reach up to divinity. And hence the famous chain of Homer (that is, the chain of natural causes) was said to be fastened to the foot of Jupiter's throne; and we see that no one has handled metaphysics and the eternal and immovable in nature, and withdrawn his mind for awhile from the variable succession of things, without falling at once on Natural Theology; so easy and near a passage is it from the top of the pyramid to matters divine.

The body of nature is elegantly and truly represented as covered with hair; in allusion to the rays of things. For rays are as the hairs or bristles of nature, nor is there anything which is not more or less radiant. This is seen most evidently in the faculty of sight, and no less in all magnetic virtue, and every effect which takes place at a distance. For whatever produces an effect at a distance may be truly said to emit rays. But Pan's hair is especially long in the beard; because the rays of celestial bodies, especially of the sun, operate and pierce from a greater distance than any other; so that not only the surface, but even the interior of the Earth for some distance, is changed, wrought, and filled with spirit by them. And that figure of Pan's beard is the more elegant, because the sun himself, when the upper part is obscured by a cloud and his rays break out below, appears to the eye as bearded.

The body of nature is likewise most aptly described as biform, on account of the difference between bodies of the upper and lower world; whereof the former, from their beauty and regularity and constancy of motion, as well as their influence over the Earth and earthly things, are properly represented by the human figure, human nature participating of order and dominion. But the latter, by reason of their perturbation and irregular movements, and because they are for the most part ruled by the heavenly bodies, may be content with the figure of a brute beast. Moreover this same description of a biform body has reference to the participation of species; for there is no natural species which can be regarded as simple; every one seeming to participate and be made up of two. Thus man has somewhat of the brute, the brute somewhat of the plant, the plant somewhat of the body inanimate; so that all things are indeed biform, being compounded of a superior and inferior species. And it is a very acute allegory, that of the goat's feet; which refers to the upward motion of earthly bodies towards the regions of the air and heaven; where also they remain hanging, and whence they are rather forced down than descend of themselves. For the goat is a climbing animal, and loves to hang from rocks and cling to the sides of precipices; a tendency which is also exhibited in a wonderful manner by substances which belong properly to the lower world; as appears most plainly in clouds and meteors. Nay a question was raised not without reason by Gilbert, who has written upon the magnet most laboriously and after the experimental method, whether heavy bodies may not, when removed to a great distance from the earth, gradually lose their downward tendency[7]?

[6] Cf. Diog. Laërt. x. 134, the reference being, as Menage, following Gassendi, remarks, to the doctrines of the earlier physicists, Democritus, etc.

[7] Gilbert was of opinion that the earth is a great magnet which attracts all bodies

Of the two insignia which Pan bears in his hands, the one represents harmony, the other empire. For the pipe of seven reeds plainly denotes the consent and harmony of things, or concord mixed with discord (which is caused by the motion of the seven planets). For there are not found any other wanderings or manifest expatiations in the heavens, besides those of the planets, such as when combined and tempered with the regularity of the fixed stars and their eternal and invariable distance one from the other, may keep up and set in motion at once the constancy of species and the continual change of individuals. And if there be any lesser planets which are not visible, or any greater change in the heaven (as in some superlunary comets), it seems they are as pipes either entirely mute or vocal only for a season ; inasmuch as their influences either do not approach so low as ourselves, or do not long interrupt the harmony of the seven pipes of Pan [8]. That sheephook also representing empire contains a noble metaphor, alluding to the mixture of straight and crooked in the ways of nature. And this rod or staff is crooked principally in the upper part ; because all the works of Divine Providence in the world are mostly brought about in a mysterious and circuitous manner, so that while one thing appears to be doing another is doing really ; as the selling of Joseph into Egypt, and the like. Moreover in all wise human governments, those who sit at the helm can introduce and insinuate what they desire for the good of the people more successfully by pretexts and indirect ways than directly. Nay (which perchance may seem strange), even in mere natural things you may deceive nature sooner than force her ; so ineffectual and self-impeding are all things which are done directly ; whereas on the other hand the indirect and insinuating way proceeds smoothly and gains its end. The cloak or mantle of Pan is ingeniously feigned to be the skin of a leopard ; because it is full of spots. For the heavens are spotted with stars, the seas with islands, the earth with flowers ; and even particular objects are commonly variegated on the surface, which may be regarded as their mantle.

The office of Pan could in no other way be so lively set forth and expressed, as by terming him the god of hunters. For every natural action, and indeed every motion and progression, is but a hunting. Arts and sciences hunt after their works ; human counsels hunt after their ends ; and all natural things hunt either after their food to preserve them, or after their pleasures and delights to perfect them (for all hunting is for the sake either of prey or pleasure) ; and this too by methods expert and sagacious :

> Torva leæna lupum sequitur, lupus ipse capellam :
> Florentem cytisum sequitur lasciva capella. [9]

Pan is also the god of all dwellers in the country, because such men live more according to nature than in cities and courts, where nature is corrupted by too

near its surface, although phenomena of polarity are only developed in a few cases. To every magnet he ascribed an " orb of virtue " beyond which it exerts no influence whatever, and also a smaller " orb of coition " such that the magnet cannot produce motion in any portion of matter which lies beyond it. As a heavy body therefore approaches the limit of the earth's orb of coition its downward tendency gradually diminishes. Imperfect as these views are, they show how clearly Gilbert had apprehended the general idea of attraction, and how little reason Voltaire had for his assertion that Bacon " a deviné l'attraction ". [See note on *Nov. Org.* p. 346.]

[8] For dreams about the music of the spheres, see Robert Fludd's work *Utriusque Cosmi, majoris scilicet et minoris, metaphysica, physica, et technica Historia*, 1617. The third book of the first tractate is wholly *De Musicâ mundanâ*, and is illustrated by an engraving of a bass viol, of which the dimensions extend through the sólar system. Bacon was, not improbably, acquainted with Fludd, who was one of the most learned of the cabalistic philosophers.

[9] Virg. *Eclog.*, ii. 63. :—The savage lioness the wolf pursues,
The wolf the kid, the kid the cytisus.

much cultivation; so that what the poet says of his mistress is by reason of such arts of luxury true likewise of nature,

Pars minima est ipsa puella sui. [10]

Pan is likewise termed the president of the mountains, because in mountains and high places nature is more open and exposed to sight and study. That Pan next to Mercury is the messenger of the gods is plainly a divine allegory; for next to the word of God, the image of the world is the herald of divine power and wisdom. "The heavens (says the Psalmist) declare the glory of God, and the firmament showeth his handiwork" [11].

Pan delights in the nymphs, that is in spirits; for the spirits of living creatures are the delight of the world. And with reason is he styled their leader, for each of them follows its own nature as a guide, round which after their own fashion they leap and frisk in endless variety and constant motion. And therefore one of the moderns has ingeniously referred all the powers of the soul to motion, and remarked on the conceit and precipitancy of some of the ancients, who in too eagerly fixing their eyes and thoughts on the memory, imagination, and reason, have neglected the Thinking Faculty, which holds the first place [12]. For he who remembers or recollects, thinks; he who imagines, thinks; he who reasons, thinks; and in a word the spirit of man, whether prompted by sense or left to itself, whether in the functions of the intellect, or of the will and affections, dances to the tune of the thoughts; and this is the frisking of the Nymphs. And in their company are ever found the Satyrs and Sileni, that is old age and youth. For all things have their merry and dancing time, and again their heavy and tippling time; and to one who truly considers them the pursuits of either age may appear perhaps ridiculous and deformed, like a Satyr or Silenus. As for the Panic terrors, a most wise doctrine is therein propounded. For nature has implanted in every living creature apprehension and fear, as the means of preserving its own life and essence, and avoiding and repelling the attacks of things hurtful. And yet this same nature knows not how to keep a mean, but is always intermixing vain and useless fears with such as are salutary; so that all things (if they might be seen within) are full of panic terrors; especially things human; and most of all among the common people, who are exceedingly troubled and agitated by superstition (which is nothing else but a panic terror), especially in hard and anxious and adverse times. Nor is this superstition confined to the vulgar, but it passes occasionally from them to the wiser sort; as Epicurus has said divinely (if only his other doctrines concerning the gods had breathed the same spirit). "It is not profane to deny the gods of the vulgar, but to apply the ideas of the vulgar to the gods" [13].

With regard to the presumption of Pan, and his challenging Cupid to wrestle, the meaning is that Matter is not devoid of an appetite and inclination to dissolve the world and fall back into the old Chaos, but that its force and malice is restrained and kept in order by the prevailing concord of things (which is signified by Love or Cupid). And therefore it falls out most luckily (or say rather by the infinite goodness of God) for man and the world, that Pan has the worst of that contest and goes away defeated. The same thing is alluded to in that other circumstance of catching Typhon in a net; because however it be that vast and strange swellings (for that is the meaning of Typhon) take place occasionally in nature,—whether of the sea or the clouds or the earth or any other body,—nevertheless all such exuberances and irregularities are by the nature of things

[10] Ov. *Rem. Amor.* 344:—So overlaid with ornament and art,
Herself is of herself the smallest part.

[11] Psalm xix. 1.

[12] The writer referred to is A. Donius. See his *De Naturâ Hominis*, 1581, the title of the twenty-first chapter of the second book of which is *Omnes Operationes Spiritus esse Motum et Sensum.* For an account of this "motus" see the sixteenth chapter of the second book. As might be supposed, Donius is altogether a materialist.

[13] Diogenes Laërt. x. 123.