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An account of Lord Bacon's Novum organon scientiarum
2nd ed.

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AN ACCOUNT OF LORD BACON'S NOVUM ORGANON SCIENTIARUM.

PART II.

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ACCOUNT OF THE NOVUM ORGANON.

THE SECOND, AND CONCLUDING PART.

HOMO, NATURÆ MINISTER ET INTERPRES, TANTUM FACIT ET INTELLIGIT QUANTUM DE NATURÆ ORDINE RE VEL MENTE OBSERVAVERIT: NEC AMPLIUS SCIT, AUT POTEST.——*Nov. Org.*

WE now proceed to give to our readers a view of the remaining part of the *Novum Organum*, as contained in the Second Book. Lord Bacon's design here is—to unfold his plan more particularly; and to convey some idea of the actual operation of that method of studying nature which he had the discernment to perceive was so absolutely essential to the advancement of all real science; and which he had the independence of mind to lay before the world, at a time when philosophers were generally devoted to hypotheses and fancies, and seemed but ill-disposed to an humble and laborious search after truth for its own sake, or to give encouragement to any one who should aspire to this arduous and honourable course.

We shall, as before, give the analysis of Bacon's doctrines, with such remarks and additional illustrations as may tend to throw light upon them. We are aware, indeed, that this part of his philosophical works has been regarded, and not unjustly, as somewhat laboured and obscure; but surely we must not forget the disadvantages under which he wrote; nor the wonderful revolution in science which he was the first instrument in effecting. It is certain, indeed, that, at the time when he flourished, the spirit of rational inquiry was not utterly unknown. In some few minds there was already a rising tendency to throw off the yoke of ancient systems, and some few instances were not wanting of the successful use of experiment; but no one had hitherto had the boldness and the genius, at once to make a formal attack on the general order of things as they existed in science, and to frame the grand and universal outline of another and a better plan. It was reserved for Bacon to proclaim aloud to the ear of Science, that she could only hope to be regenerated by first sacrificing herself on the altar of Truth; and that if ever she took an upward flight, she must pass a fiery ordeal, and rise like a phœnix from her own ashes.

Bacon, in this respect, stood alone; and if his *New Machine of the Sciences* appear, on more minute examination, to be somewhat cumbrous and defective, it was still a mighty effort to have devised such an instrument at all. If the genius of the new philosophy first issued from the thick darkness of the middle ages, wearing the garb and speaking the cramp language of the schools, this was perhaps an unavoidable consequence attaching to the period of its birth. The enlightened style of philosophy which now prevails, is certainly nothing more than the spirit of what Bacon taught, freed from all needless technicalities and incumbrances; and exercising, to the best advantage, its own proper energies. If Bacon did not perfectly exemplify his own rules of philosophizing, and if we sometimes see, as is certainly the case, the remains of ancient error in his conclusions, we should remember that he kindled the broader light we now act in, and which makes us discern clearly the imperfections of his own method. It is he who has enabled us to consider as ordinary and manifest truths, propositions utterly denied to his predecessors; and to complain of things as obscure, which to him were new, and were seen across the settled and distorting mist of error, and to us are clear only through the purer medium of his philosophy.

The second book of the *Novum Organon* may be divided into three parts; which comprise Aphorisms, or remarks on what is termed *the Discovery of Forms; Tables* in illustration of this discovery; and the *Doctrine of Instances.*

Section I. *Of the Discovery of Forms, or Causes, in Nature.*

AFTER the primary object of ascertaining *facts*, or collecting the history of nature with regard to any subject of inquiry has been effected, the next aim proposed is, by comparing these different facts, to produce certain *changes* in matter; and to discover the ultimate *causes* on which its qualities depend. "The object and aim of human power," says Bacon, "is to produce a *new nature*, or natures on a given body; and the object and aim of human knowledge is to discover the *form* of a given nature; that is, its real difference; the nature which makes it what it is (*naturam naturantem*), or, the source whence it flows."

The scholastic word *form* here employed is borrowed from the Platonists, though with a meaning different from theirs. Plato and his followers adopted the notions before held by the Pythagoreans with respect to *forms, ideas,* and *essences;* and regarded the various configurations, or shapes of matter, as nothing more than copies of their *essences*, or *ideas*, as existing in the divine mind. Thus, for example, since the squares or circles actually drawn by the mathematician are never absolutely accurate, they supposed that their true *archetypes* or *patterns* are to be found subsisting by themselves in the mind of the Deity. Now Plato, and his school, maintained that this perfect *intellectual world* was discoverable by contemplation; and that while the visible creation is the object of *sense*, these ideas, or essences—the *forms* of things abstracted from matter,—are the proper objects of *science*. Bacon, in his work on the *Advancement of Learning*, while he pays the tribute of praise due to Plato's genius, condemns, as well he might, his mystical philosophy; and intimates that the *forms* which he himself proposes to discover are to be found *in* matter, and not *out* of it. In another passage in the *Novum Organon*, he expressly defines what he means by *forms*, in the following manner:—"When we speak of *forms*, we understand nothing more than those *laws* and *modes* of action which regulate and constitute any simple nature; such as heat; light; weight; in all kinds of matter susceptible of them: so that the *form* of heat, or the *form* of light, and the *law* of heat, or the *law* of light, are the same thing; nor do we ever lose sight of practice, and things as they are."

"The form of any nature" is, in another place, defined to be "such, that where *it* is, the given *nature* must infallibly be. The form is perpetually present when that nature is present; ascertains it universally, and accompanies it every where. Again, this form is such, that when removed, the given nature infallibly vanishes: therefore the form is perpetually wanting where that nature is wanting; and thus confirms its presence or absence, and comes and goes with that nature alone."

In the language of Bacon, then, the *form* of any substance is its *essential nature*—the *form* of any quality is that which constitutes that quality. Thus, if the subject of investigation were the quality of *transparency* in any substance, the *form* of it is something of such a nature that, wherever it is present, there is transparency; and wherever there is transparency, that which is here scholastically termed the form, is likewise present. The *form*, he says, is the same thing, as regards our knowledge, with the *cause;* not limiting the meaning of this word to the *antecedents* or *circumstances* which immediately produce a succession of *events* or *changes* in matter, but including also the source from whence *permanent qualities* in body are derived. In short, the *discovery of forms* may be regarded as signifying the discovery of the *laws of nature* in general.

It may serve to facilitate our apprehension of Bacon's ideas, if we carry along with us the remark, which has not improperly been made, even by his greatest admirers—that he appears, from the language he sometimes employs with regard to forms, to have placed the ultimate aim of philosophy beyond what it is, in all probability, given to man to reach, however rigidly he may employ his faculties, according to the method here recommended. He seems to think that a knowledge of the *ultimate essences* of the qualities, and powers, or properties of matter, lie open to human scrutiny; that we can discover, for instance, wherein consists the *essence* or *nature* of *transparency;* of *cold;* of *heat;* of *colour.* Upwards of two centuries, however, have rolled away under the auspices of Bacon's system; and no one would as yet affirm that we have actually arrived at the boundary of nature, so as to have discovered the essence of matter itself, or of any one of its various modifications. We are still ignorant, strictly speaking, of the *causes* of the various operations of nature, after ages of laborious and scientific investigation; nor will the philosopher profess to have ascertained, with regard to any one series of these causes, or successive events and changes, that he has, beyond all possibility of doubt, at length arrived at the beginning of the series; that he has laid his finger on the ultimate link in the whole chain which is held by the hand of Omnipotence; and that he has traced the identical point at which these second causes merge, and are lost in the secret agency of the great First Cause of all; if indeed it be not more proper to consider all second causes as nothing more than so many constant actions of the Deity, regulated by his own laws.—In the case of *heat*, for instance,—by conducting inquiries in the spirit of the inductive method, many of the effects and properties of this powerful agent have been discovered; but its *form*, to use Bacon's language, or, in other words, *what heat is*, has not been ascertained. Perhaps a complete knowledge of its essence might, even if it could be known, conduce less to practical uses, than we may be ready to imagine: certain it is, however, that the question still remains undetermined, whether heat be a subtile fluid, and therefore of a *material* nature; or, as Bacon himself supposed, nothing more than a certain *motion* among the particles of bodies.

The same remark is applicable to the other great agents in nature, as *gravity, electricity, light, magnetism, elasticity.* Perhaps our notion of gravity is as simple as any, since its *one* property is the law of its decrease with the square of the distance; but whether this, and the rest have, or have not, any second causes beyond themselves, none presumes to say. While it would be unphilosophical to assert that more *can never* be known of these agents than what is already ascertained, it may be observed that, even should Bacon's aims, as to the discovery of forms, always prove to have been too high for mortals to fulfil, this is no disparagement whatever to his method, which still remains applicable to the investigation of causes, to the uttermost limits that can be reached by the perseverance and ingenuity of man.

"To the discovery of forms," proceeds Bacon, "belongs that of the *latent process* (*latens processus*); continued from the manifest producing cause of changes in bodies, and what is obvious to the senses, up to the giving of the form itself," that is, the ultimate law of nature in the particular case; or, at least, what appears to be that law: "there also," he adds, "belongs to it the discovery of the *secret structure,* (*latens schematismus,*) of bodies that are *quiescent* and exhibit no motion. The *latent process* we speak of does not here mean certain visible measures, or signs, or steps of procedure in bodies, but a perfect continued process, the greatest part of which escapes the sense. Thus, for example, in every generation and transformation of bodies, it comes to be inquired, what is lost, or flies off; what stays behind; what is added; what dilated; what contracted; what united; what separated; what continued; what cut off; what impels; what obstructs; what prevails; what yields, etc.: nor are these things only to be sought in the generation, or transformation of bodies; but, after the same manner, it comes to be inquired in all other alterations and motions, what precedes; what succeeds; what is quick; what slow; what gives motion; what governs it; and the like. But all these things remain unknown and untouched in the sciences, which are at present formed in a very gross and perfectly inadequate manner."

This *latent process*, undoubtedly a grand object of philosophical inquiry, to the farthest verge of human power, is, therefore, in modern language, the invisible and secret progress by which sensible changes are produced; and involves what has been termed the *law of continuity;* that is, the law by which quantities which change their bulk, or their places, do so, not abruptly, as in many cases may seem to us, but by passing through all the intermediate magnitudes, or distances, till the change be completed. In other words, all changes, however small, must be effected *in time.* We see this in innumerable operations of nature, such as the *planetary movements;* the phenomena of *accelerated velocity* in falling bodies; the *motion of light*, shown by the eclipses of Jupiter's satellites; in the progress of *disease*, in which there is a change of the structure of the parts. The late Professor Playfair remarks on this subject, "to know the relation between the time and the change effected, would be to have a perfect knowledge of the latent process;" the meaning, of course, is, if we could know all the *minutest* changes: for we may know, by experience, how much *time* it may take to effect a *given* change on matter, without knowing what *intermediate* changes may have led to the given one. In explanation of Bacon's doctrine, Mr. Playfair adds, "in the firing of a cannon, for example, the succession of events during the short interval between the application of the match, and the explosion of the ball, constitute a latent process of a very remarkable and complicated nature, which, however, we can now trace with some degree of accuracy. In mechanical operations we can often follow this process more completely. When motion is communicated from any body to another, it is distributed through all the parts of that other, by a law quite beyond the reach of sense to perceive directly, but yet subject to investigation, and determined by a principle which, though late in being discovered, is now perfectly recognised. The applications of this mechanical principle are perhaps the instances in which a latent, and indeed a very recondite process has been most completely analysed." The allusion here is to the laws which regulate *percussion*, *collision*, and the *communication* of *motion* in bodies.

What Bacon terms the *latent schematism*, or structure of bodies, is that unseen shape and arrangement of their parts on which, it is obvious, so many of their properties must depend. The internal structure of plants, and the constitution of crystals, are instances; an inquiry into these is an inquiry into what is here quaintly termed the *latent schematism;* as also such an inquiry into *electricity*, *gravitation*, *magnetism*, etc., as would be directed towards the attempt to explain these facts, by any peculiar structure of bodies, or any arrangement of the particles of matter. "The inquiry," says Bacon, "and discovery of the concealed structure in bodies, is as much a new thing as the discovery of the latent process, and form; for men have hitherto trodden only in the outer courts of nature; and are not prepared to enter within. But no one can superinduce a new nature on a given body; or successfully and appositely change it into another body; unless he has first a competent knowledge of the body to be altered or transformed."

It must be confessed that Lord Bacon, emerging as he did from the prejudices of those ages in which philosophers pretended to account for almost everything, seems not only to have anticipated, as we have already observed, a greater perfection in human knowledge than it will probably ever attain, but also to have somewhat mistaken the way in which knowledge is to be converted to practical purposes. He supposes that if the *form*, or cause, or law, of any quality were known, we should be able, by inducing that "form" on any body, to communicate to it the said quality. It is not obvious, however, that even this knowledge would necessarily conduce to more simple and advantageous methods, than those of which the arts now furnish so many specimens. We are quite ignorant, for instance, on what *colour* in bodies precisely depends—what peculiar construction of surface it is, which makes a body reflect one particular species of light rather than another; yet we know how to communicate this quality from one substance to another. Would a knowledge of that concealed structure, on which this reflection depends, enable us to impart it to bodies more easily than we are able to do by immersing them in a liquid of a given colour?

Lord Bacon proceeds to make some remarks upon several of those *changes* in bodies, which he seems to have considered it within human power possibly to produce. He partly draws his illustrations from the pursuits of the alchemists; and makes some suppositions savouring to us a little of paradox, though we cannot but discern his great sagacity, and admire his persevering diligence, amidst all the disadvantages under which he laboured. "We shall examine," says he, "what kind of rule, direction, or leading, a man would principally wish for, in order to superinduce an assigned nature upon a given body; as if any one should desire to superinduce upon silver the yellow colour of gold; and to increase its specific gravity; or to superinduce malleability upon glass; or vegetation upon a body not of the vegetable kind."

"The rule for the transmutation of bodies is of two kinds. The *first* regards a body as a certain collection, or combination of *simple natures* (*properties*). Thus, for example, in gold, there meet together yellowness; a determinate gravity; malleability to a certain degree; fixedness in the fire; a particular manner of flowing in the fire; a determinate way of solution, etc., which are the simple natures (properties) in gold. For he who understands forms (causes), and the manner of superinducing this yellowness, gravity, ductility, fixedness, faculty of fusion, solution, etc., with their particular degrees, and proportions, will consider how to join them together in some body, so that a transmutation into gold shall follow."

"But the *second* kind of rule, which depends upon discovering the *latent process*, proceeds by *concrete bodies*, such as they are found in the ordinary course of nature: for example,—when inquiry is made from what origin, by what means, and in what procedure, gold, or any other metal, or stone, is generated from its first fluid matter, or rudiments, up to a perfect mineral. Or, again, by what process plants are generated, from the first concretions of their juices in the earth, or from the seed to a formed plant; together with the whole succession of motion, and the various and continued endeavours of nature. And this inquiry does not only regard the generation of bodies, but likewise other motions and works of nature: for example,—when inquiry is made into the whole series and continued actions of nutrition, from the first receiving of the aliment to a perfect assimilation; or, after the same manner, into the voluntary motions of animals, from the first impression of the imagination, and the continued efforts of the spirit, down to the bending and moving of the limbs; or again, in explaining the motion of the tongue, lips, and other organs, up to the formation of articulate sounds. For these things, also, have regard to concrete natures, or natures associate and organical.—And where mankind has no power of operating, but only of contemplating, yet the inquiry of the fact, or truth of the thing, belongs, no less than the knowledge of causes and relations, to the primary and universal axioms of simple natures: suppose, for example, the inquiry about the nature of spontaneous rotation, attraction, and many other natures; which are more common and familiar to us than the celestial bodies themselves. And let no one expect to determine the question whether the diurnal motion belongs to the heavens, or to the earth, unless he first understand the nature of spontaneous rotation."

The above passages, while they furnish an example of that acuteness and comprehension which so eminently distinguished their author, are not free from indications of his propensity to expect too much from human ingenuity, and to place the evidence of truth, in some respects, too high. His remark, for instance, with regard to the "nature of *spontaneous rotation*," whatever idea he attached to it, as belonging to the celestial motions, may account, in some measure, for his prejudice against the doctrine of *Copernicus*, which attributed the diurnal motion to the earth, and not to the heavens; and which had been published to the world many years before Bacon flourished. Indeed, a proneness to form boundless expectations as to what human power might effect; and, in the very infancy of practical science, to look for achievements higher than we can, even in its more advanced age, venture to hope for, is one of the most remarkable features in the elevated and daring genius of this great man.

Further, to explain his views with regard to the inquiry into the *latent structure* of bodies, he points out what he conceives to be some of the proper objects on which this minute investigation may be instituted, as iron and stone; the root, leaves, and flowers of plants; the flesh, blood, and bones of animals. *Distillation*, and other methods of separation, are instances, as collecting together the different homogeneous or similar particles of the same body. He here, however, acutely cautions the chemists of his day against supposing that all the natures (qualities) which may be exhibited in the separation of the parts of any substance, must have existed in the compound; new natures (properties) being often superinduced by heat, or some other method of resolving bodies; "for this structure," he observes, "is a thing of great delicacy and subtilty, and may be rather confounded, than discovered and brought to light, by the operations of fire." He adds, in his usual serious and imaginative style: "Bodies, therefore, are to be separated, not (merely) by fire, but by reason, and genuine induction; with the assistance of experiments; for we must go over from Vulcan to Minerva, if we would bring to light the real textures and structures of bodies."

On the sanguine expectations and lofty aims which Lord Bacon indulged, with regard to what human industry and perseverance might effect, he proposes to found what he terms the "just division of philosophy, and the sciences," into *metaphysics* and *physics*. "The inquiry of *forms*," he says, "which, from the reason of the thing itself, and their own law, are eternal and immutable, may make *metaphysics*; and the inquiry into the efficient cause, the matter, the *latent process*, and the *latent structure*, may constitute *physics*, since these several (latter) particulars regard the ordinary course, and not the fundamental and eternal laws of nature." Certain it is, that however just such a general division of all human knowledge might be in Bacon's sense of it, could we realise his ideas and aims as to the *discovery of forms*, no progress has, as yet, been made towards the hopeful attainment of such a system of metaphysics; and probably the more secret operations of nature may for ever remain so shrouded from human penetration, as to render it impossible to say, in any one instance, that we have reached the goal, ascertained the very *first* in the series of second causes, and drawn the exact line between the subordinate operations of matter, and the immediate agency of the Infinite Spirit.—The following passages, on the "*raising of axioms, or principles from experience*," are introductory to the tables in which Bacon has exemplified his own method of induction, in an inquiry into the "form" of *heat*; or, in what heat consists.

"The raising of axioms from experience is divided into three kinds of administrations or helps; 1. for the sense; 2. for the memory; and 3. for the reason."

(1.) "Therefore, a just and adequate natural and experimental history is to be procured, as the foundation of the whole thing; for we are not to fancy or imagine, but to discover what are the works and laws of nature."

(2.) "Such history must be digested and ranged in proper order; therefore tables and subservient chains of instances are to be formed in such manner, that the understanding may commodiously work upon them."

(3.) "And though this were done, yet the understanding, left to itself, and its own spontaneous motion, is unequal to the work, and unfit to take upon it the raising of axioms, unless it be first regulated, strengthened, and guarded; therefore, in the third place, genuine and real induction must be used as the key of interpretation."

"The inquiry of *forms* proceeds in this manner. First, all the known instances, agreeing in the same nature, though in the most dissimilar subjects, are to be brought together, and placed before the understanding. And this collection is to be made historically, without any overhasty indulgence of speculation, or any great subtilty for the present. We will illustrate the thing by an example in the inquiry into the *form* of heat."

Section II. *Of the Tables given in Illustration of the Inductive Method.*

The materials from which Lord Bacon designed that *tables* of this kind should be composed, for the future advancement of science, were such as he himself has sketched out in his book entitled, after the quaint fashion of the time, *Sylva Sylvarum*, or "A Natural History; in Ten Centuries;" each of the ten sections into which it is divided containing one hundred facts and experiments, relating to a great variety of subjects; the term *natural history* being here used in a very extensive sense, to signify a record of observations on nature in general.

Such a history of facts as that from which tables should be drawn, was to contain an account of the subject under examination, in all the varieties and modifications of which the appearances belonging to it were susceptible. Not only were these facts in nature to be included in it, which offer themselves at once, and of their own accord, to the senses, but also all those experiments which might be instituted for the discovery of new facts relating to the same inquiry. These facts and experiments were to be ascertained with the greatest care; faithfully and simply stated, without mixing up any theory with the narration of them; and distinctly arranged. If any thing rested on doubtful evidence, this was not to be altogether excluded from the history of the subject, but to be noted down as uncertain, together with the reasons for so regarding it; and it was not to be employed as evidence in the discovery of *forms*, or ultimate causes, till rendered more probable by other facts, on which there rested nothing doubtful. In short, this *history* of nature was to be, as much as possible, a copy of nature herself, both as regarded obvious facts, and actual experiments; for, in experiments, as Bacon observes, "man does nothing more than bring things nearer to one another, or carry them farther off; the rest is performed by nature." This remark has its exemplification in such operations as the firing of a pistol, the discharge of an electrical jar, and in all the experiments of chemistry, in which the art of man does no more than commence the process by applying the spark to the gunpowder, or by causing the connection between the inside and outside of the jar to be produced, or the electric circle to be completed; or by bringing the chemical agents into contact with each other; the rest is done by nature herself.

It must be acknowledged that a single glance into the *Sylva Sylvarum* will convince the reader that it is far from answering to the standard which its great author sets up for regulating the collection of the materials of scientific inquiry. In his "Experiment Solitary touching the commixture of flame and air, and the great force thereof," he says, "As for living creatures, it is certain their *vital spirits* are a substance compounded of an airy and flamy matter. It is no marvel that a small quantity of spirits in the cells of the brain, and canals of the sinews, should be able to move the whole body, which is of so great mass; such is the force of these two natures, air and flame, when they incorporate." It is unnecessary to adduce other specimens, many of which are to be found, as fanciful in matter, as vague in statement, and as gratuitous in evidence; in a word, exhibiting as complete a departure from the severity of the inductive method. Yet, amidst this indigested mass of facts and fancies, it is impossible not to discern the unwearied diligence, the acuteness, the boundless curiosity, and insatiable appetite for knowledge, which Bacon possessed. It is interesting to see the energies of such a mind grappling with the difficulties which inevitably surrounded it; eager for liberty, beneath the shackles that cramped its exertions; panting for the pure air of truth, amidst those oppressive mists of error which beset it on all sides; and more readily taking up with error, from its very impatience for truth. Bacon's faults as a practical natural philosopher, the occasional credulity and love of theory which he manifests, are only the more remarkable from his having so admirably descanted on those very errors by way of speculation. To free himself from the actual dominion of error in natural science, even though he had such lofty general conceptions of truth, was perhaps impossible in his situation. The morning star of nature is, in the language of Milton, "last in the train of night," though it belongs "better to the dawn;" and the sun himself cannot shake off the mists that attend his rising—time is needed to dispel them: Bacon was the first grand luminary of science, and it was no wonder that a portion of the darkness of the middle ages should still cling around him.

Nor was he himself unaware of the imperfection of those crude and recent materials from which, for want of collections of facts sufficiently accurate and long-established, he was obliged to deduce his tables. Perhaps, what he chiefly intended was a rough sketch of the history of nature, leaving it to posterity to follow out his plan with greater accuracy, and with all the advantages of time. This appears, indeed, from the caution which he gives his readers, quoted in our former Treatise on this work, not to reject his method itself, because some experiments and facts may not be so well verified as might be wished; or others even absolutely false. The same may be gathered from the following remarkable passage in the Preface to the *Sylva Sylvarum*, by Dr. Rawley, who was Lord Bacon's chaplain. "I have heard his Lordship often say, that if he should have served the glory of his own name, he had been better not to have published this Natural History; but that he resolved to prefer the good of man, and that which might best secure it, before any thing that might have relation to himself. And, in this behalf, I have heard his Lordship speak complainingly, that his Lordship, who thinketh he deserveth to be an architect in this building, should be forced to be a workman and a labourer, and to dig the clay and burn the brick; and to gather the straw and stubble over all the fields to burn the bricks withal. For he knoweth that except he do it, nothing will be done; men are so set to despise the means of their own good."

Lord Bacon formally *exemplifies* his method of induction in this part of the *Novum Organon*, on the subject of *heat*—his object being to inquire, what is its *form* or *nature?* In order to institute this inquiry, he arranges the facts and experiments he was acquainted with relating to it, in *five different tables.* These tables, while they partake of all the imperfections found in the *Sylva Sylvarum,* can scarcely be denied the praise, as Professor Playfair remarks, of being "extremely judicious," while the whole disquisition, as the same excellent judge observes, "is highly interesting."

Tab. I.—The *first* table contains instances in which heat is found and is termed, by the author, the "*Affirmative Table;*" or "*Instances that agree in possessing the nature of heat;*" and here are enumerated the sun's rays, direct and reflected; fiery meteors; lightning; flame; ignited matter; hot springs, and heated fluids in general; sultry seasons; subterraneous air; the coverings of animals; all bodies exposed to the action of fire; sparks struck out by collision; matter in a state of friction, as the wheels of carriages; green and moist plants when pressed together, as hay; slaked lime; iron in a state of effervescence with acids; the bodies of animals; herbs that are hot to the taste, as cresses: vinegar also is added, as applied to the flesh; and even intense cold producing a burning sensation.

Tab. II.—The *second table* which Bacon proposes in pursuit of his method, is *negative;* containing a list of *things in which heat is not found:* but, for the sake of brevity, the examples here introduced are to be only of those things which have a *near relation and resemblance* to the things mentioned in the first table, *heat* alone *excepted,* in which they are, to all sense, wanting. Thus, the first example of the "*instances agreeing in possessing heat,*" were the *sun's rays;* and the parallel *negative* instance, or the first mentioned in the *second* table, are the *rays of the moon,* of *stars,* and of *comets,* since these are all luminous, though less so than the rays of the sun, but are *without heat.* In like manner, every instance in which heat *exists* in the things enumerated in the *first* table, is to have one or more parallel instances in the *second,* in which heat is *wanting;* though the substances in both the tables seem nearly related to each other.

Tab. III.—The *third table* consists of a *comparison of the degrees of heat* found in different substances. The things first to be considered are such as discover no heat whatever to the touch, but seem only to have, says Bacon, "a certain *potential heat, or a disposition and prepara-*

tion towards actual heat." Quicklime, green plants, acrid vegetables, etc., are mentioned as examples. The first degree of heat sensible to the touch, he considers to be that of *animals;* and inquiry is to be made respecting the comparative heat of the different kinds of animals, and of different parts of the same animals; and the causes by which animal heat is increased. The degrees of heat in various kinds of *flame* are also to be observed; as in the flame of alcohol; of porous vegetables; of wood; of unctuous substances, as oil and tallow; of pitch and resin; of sulphur; of gunpowder; of imperfect metals, as regulus of antimony; and of lightning. Also the degrees of heat in *ignited* bodies, as in tinder, coal, and metals. The thermometer (*vitrum calendare*), which was just come into use when Bacon wrote, is mentioned as showing the extreme aptitude of the common air to receive and communicate heat; being affected by the slightest change of temperature. Next to the air, those bodies were imagined to be most sensible of heat which had been newly changed and condensed by cold, as snow and ice; then is mentioned conjecturally quicksilver; next unctuous bodies, as oil and butter; afterwards wood; water; and lastly, stones and metals, as not heating so easily, though they retain their heat a long time.

This table, while it discovers, like the rest, the exhaustive genius peculiar to its author, and the enlarged general views which he took of the subject of inquiry, possesses the same defects as it regards accuracy in the facts; and occasionally the same insensible tendency to theorize. It appears singular enough, for instance, to us, who know the property which oxygen has of sustaining combustion, that the increase of heat should be accounted for mechanically thus: " Motion increases heat, as appears by bellows and blow-pipes;" and that after a description of the thermometer, and the sensibility of the air in respect of heat and cold, it should be added, " but we conceive that the spirit of animals has a still more exquisite sense of heat and cold, unless it be obstructed and blunted by the grosser matter of their bodies." Yet it is here remarked—" How unprovided we are in natural and experimental history, may be easily observed from hence; that in the preceding tables we are frequently obliged to direct experiments and further inquiry into particulars; and that, instead of approved history, and such instances as may be depended upon, we are sometimes driven to insert *traditions*, and *stories*, though we do this with a manifest doubting of their truth and authority."

These *three tables*, containing a great number of such *positive*, *negative*, and *comparative* examples on the subject of heat as we have quoted, are designed, Lord Bacon says, to " present a view of instances to the understanding." And when this view is procured, the business of *induction* is to be put in practice. " For, upon a particular and general view of all the instances, some quality or property is to be discovered, on which the *nature* of the thing in question depends, and which may continually be present or absent, and always increase and decrease with that nature; and limit the more common nature. God, the giver and Creator of *forms*, doubtless knows them by immediate affirmation, and at the first glance; and so, perhaps, may angelic intelligences; but this is certainly beyond the power of man, to whom it is given to proceed, first, by *negatives* only, and after a perfect exclusion by *affirmatives.* We must therefore make resolution and separation of nature, not by fire, but by the mind, which is, as it were, the divine fire. And thus the *first* work of genuine induction in the *discovery of forms*, is to throw out, or exclude, such particular *natures* as are not found in any instance where the given nature is present; or such as are found in any instance where that nature is absent; and again, such as are found to increase in any instance when the given nature decreases; or to decrease when that nature increases. And then, after this rejection and exclusion is duly made, the affirmative, solid, true, and well-defined form will remain as the result of the operation, whilst the volatile opinions go off, as it were, in fume. And if any one shall think that our forms have somewhat abstracted in them, because they appear to mix, and join together things that are heterogeneous, as the heat of the celestial bodies, and the heat of fire; the fixed redness of a rose, and the apparent redness of the rainbow, or the opal; death by drowning, and death by burning, stabbing, the apoplexy, consumption, etc., which, though very dissimilar, we make to agree in the nature of heat, redness, death, etc., he must remember that his own understanding is held and detained by custom, things in the gross, and opinions. For it is certain that the things above-mentioned, however heterogeneous and foreign they may seem, agree in the *form* or *law* that ordains heat, redness, and death."

The first step, therefore, according to Bacon, in an inquiry into the *form* or *cause* of any thing by induction, is to consider what things are to be excluded from the number of *possible* forms or causes. This exclusion contracts the field of inquiry, and brings the true explanation of the case more within reach. Thus, suppose the subject in question be, to use the language of our author, the form of *transparency;* or in other words, the quality which is the *cause* of transparency in bodies: now since the *diamond* is transparent, we immediately exclude *fluidity*, and *porosity*, or *rarity;* because the diamond is a very solid and dense substance: that is, a body may be transparent, without being either fluid or light, compared with other bodies; neither fluidity nor lightness, then, are the form or cause of transparency.

Tab. IV.—Bacon's *fourth table*, accordingly, proposes to exhibit "an example of this exclusion, or rejection of natures from the form of heat; that is, a rejection of those things as the *causes* of heat, in which it evidently cannot consist. Thus, as both the sun's rays and common fire are hot, he excludes both "terrestrial and celestial nature." *Light* and *splendour* are also rejected as essential to heat, because water, air, and solid bodies will receive or conduct heat without being ignited; and, on the contrary, the rays of the moon and stars present light without any sensible heat; also because ignited iron is less lucid, but hotter than the flame of alcohol. Again, *tenuity*, or a certain lightness of substance, is to be excluded as the cause of heat, because gold, which is very dense, can be ignited; while the air, which is generally cool, is thin and subtile. *Expansive motion* is also to be rejected, Bacon says, "because ignited iron enlarges not in bulk, but remains of the same dimension;" this, however, is contrary to a well-known fact in the economy of heat.—As bodies are warmed without *destruction of the parts*, this destruction is to be excluded. Other things also are to be rejected, "for our tables," says the author, "are not designed as perfect, but only as examples."

Hence, it is added, at the end of this table, "The business of exclusion lays the foundation for a genuine induction, which, however, is not perfected till it terminates in the affirmative; but an exclusion is by no means perfect at first, nor can it possibly be so; for exclusion, as we plainly see, is the rejection of *simple natures;* and if we have hitherto no just and true notion of simple nature, how can the business of exclusion be rectified? But some of the above-mentioned notions, as those of *elementary* (or terrestrial) nature, *celestial* nature, and *tenuity*, are vague and ill-defined. Wherefore we must proceed to greater helps for the mind. And yet we judge it useful to allow the understanding to apply itself and attempt the business of interpreting nature in the affirmative, on the strength of the instances contained in these tables, and such as may be otherwise procured. And this kind of attempt we call a *permission of the understanding*, the rudiments of interpretation, or the first vintage of inquiry."

Tab. V.—The next, which is the *fifth table* and the last, is accordingly quaintly entitled, "*The first Vintage concerning the Form of Heat;*" that is, a rough and general specimen of a conclusion derived from the foregoing investigation. Bacon concludes, here, that from an examination of all the instances, "separately and collectively, *the nature whose limitation is heat, appears to be motion,*" which he attempts to prove from the view he took of the facts. He adds, "what we have thus said of motion is to be understood of it as of a *genus*, with regard to heat, and not as if heat generated motion, or motion generated heat, though this may be true in some cases; but the meaning is, that *heat itself*, or the very existence of heat, *is motion*, and nothing else, though motion limited by differences, which we shall presently subjoin."

He next points out these "*differences*," as he terms them; that is, he endeavours to discover what *kind* of motion this is of which he speaks. He *first* argues that it is *expansive*, whereby a body dilates itself; which, however, is hardly consistent with his observation on ignited iron in the fourth table. The *second* "difference," or quality of the motion is, that heat is an expansive motion toward the circumference, and which at the same time rises upwards. "The *third* difference," he says, "is that this motion is expansive in the lesser particles of a body;" and "the *fourth* difference is, that the motion in which heat consists is rapid." All this he attempts to prove, and concludes thus: "Let this serve for what we call the first vintage, or an attempt towards interpreting the form of heat, which the understanding makes, as we said, by way of permission. The fruit of this first vintage is in short: Heat is an expansive, bridled motion, struggling in the small particles of bodies. But this expansion is modified; so that, while it spreads in circumference, it has a greater tendency upwards. It is also vigorous and active. And as to practice, if, in any natural body, a motion can be excited which shall dilate or expand, and again recoil or turn back upon itself, so as that the dilatation shall not proceed equally, but partly prevail, and partly be checked, any man may doubtless produce heat And this may serve as an example of our method of investigating Forms."

Notwithstanding the imperfection of these tables as to their detail, the want of accuracy in the experiments, the crudeness, and the apparently gratuitous style of Bacon's conclusions, amidst the laboured appearance of the whole, it is worthy of remark that his hypothesis on the nature of heat is the very same as one of those which still, at the distance of nearly two centuries, divide the opinions of philosophers. The more direct and elegant manner in which the moderns have employed his inductive method, has not, in the very instance which he first chose as an example of it, enabled them to go one single step beyond him. It is still a question, whether heat be really *matter*—a subtile fluid capable of diffusing itself in bodies; or any thing more than a *motion*, vibration, or rotation, excited among their particles. All the experiments that have been made up to the present time, have not availed to set the question at rest; and the greater part of the facts relating to heat may be explained equally well on either of the two suppositions.

Section III.—*Of the Doctrine of Instances, or Facts, as regards the Discovery of Forms.*

It is obvious that *all* facts, however well authenticated they may be, are not of equal importance in the discoveries of science. Some facts are so like others, that it may be quite unnecessary to notice them. Some exhibit the subject of inquiry in its most simple state; others present it with a combination of circumstances. In some cases the thing sought appears in its highest degree; in others in its lowest. In medicine, for instance, a disease sometimes presents itself in its purest form, and most regular progress; at other times it is involved in a variety of other symptoms that do not belong it. Hence Lord Bacon proposes to consider what he calls *Prerogativæ Instantiarum, Prerogative Instances;* or the *comparative value of facts* as means of discovery, or instruments of finding truth.

The design here is to show what are the *most important* and essential *particulars* in every inquiry; or what instances in the operations of nature are chiefly to be sought for, and attended to, in order to discover the laws of nature in general, to whatever extent man may be able to ascertain them. The conclusion on the subject of heat being only to be regarded as an *example*, and not as a perfectly established truth, Bacon retraces, in a manner, his own steps, and proceeds to treat, generally, and more accurately, of the way of procuring a proper collection of such facts, experiments, and observations, as are best fitted to constitute *affirmative*, *negative*, and *comparative* tables, like those we have described; and this in order, ultimately, to shorten the inquiry, and to render it more rigid.

We shall now give our readers an outline of these "*Prerogative Instances;*" or those cases which have a chief claim to be noticed in the attempt to interpret the laws of nature; retaining the terms which Bacon figuratively applies to them. He divides them into three classes, which he denominates those which address themselves to the *understanding;* those which assist the *senses;* and those which conduce to *practice.*

I. *Instances addressing themselves to the Understanding.*

1. The first are the *Instantiæ Solitariæ; solitary* instances. These are divided into *two* classes.—The *first* are those examples in which the the *same* "nature," or quality, exists in different bodies, which have

nothing in common but that quality; that is, the bodies differ in all things but in this one. The conclusions that can be entertained in this case, respecting the *form* or cause of this quality, are limited, inasmuch as they involve none of the things in which the bodies differ, but only that in which they all agree. Crystals, prisms of glass, and dew-drops, are *instantiæ solitariæ*, because they exhibit colour, in some situations, while they have nothing in common with stonés, metals, wood, flowers, etc., whose colours are fixed, excepting the colour itself. Hence Bacon infers that colour is, in the first substances, that is, in crystals, etc., simply a modification of the rays of light, produced by the different degrees of *incidence*, or the angles which light makes in falling on them; and in the latter case, as in stones and metals, he concludes that colour depends on the texture and structure of the surface. It was by these examples that Newton afterwards discovered the composition of light.

The *second* class of *solitary instances* are the reverse of the former. They are those cases in which the "nature" or quality, which is the subject of inquiry, *differs* in two bodies which are in all other respects the same; that is, the bodies here agree in all things but this one. The *form* or cause here, therefore, cannot exist in any of the general things in which the bodies agree. The veins of black, and of white, in marble, and the variety of colours in flowers, are adduced as examples; where the substances agree, almost in everything but in colour. Bacon here again concludes that permanent colours depend chiefly on the texture of the surfaces of bodies, and very little on their internal and essential properties.

2. *Instantiæ Migrantes*, or *travelling* instances, are those in which one quantity is lost, and another is produced; or, in which the nature or quality inquired into exhibits changes and degrees, passing from less to greater, or from greater to less; in the one case approaching its *maximum*, or greatest state, in the other tending to extinction altogether. Let the inquiry be into the cause of *whiteness*, in bodies that are of this colour. *Glass* and *water* are mentioned as examples. Glass, when whole, is without colour; but, when powdered, becomes *white:* so water in its natural state is colourless, but is white when in the state of *foam*. Both these substances pass from a state of transparency to an opaque state. "It is manifest," says Bacon, "that the form (cause) of whiteness travels or is conveyed over by pounding the glass, and agitating the water; nothing, however, is here found but a bare comminution of the parts, together with the interposition of the air; and whiteness is exhibited by a different refraction of the rays of light." Metals becoming *fluid* by heat, and again *solid* by its abstraction, might be added as another example. Also the *shells* which are often found perfect in limestone, and by degrees become lost in the finer marbles, till they are no longer discerned. The mineral kingdom presents *this* kind of instances in the greatest abundance, and such facts are, perhaps, nowhere of greater importance in practice. The barometer also furnishes an instance of this *progressive* kind; for on going to the top of a mountain the mercury sinks, which it ought to do, if it be the weight of the atmosphere that supports it, because the column of the atmosphere is now shorter.

3. Next come the *Instantiæ Ostensivæ, glaring* instances; which our

author also terms *eluscentiæ*, and *predominantes*, or instances which shew the *nature* or quality in its highest power and degree, and freed from the obstructions which usually counteract it. The nature which is the subject of inquiry is here, as is represented, fully displayed, either by the absence of such obstructions to it, or by its prevailing over them by its own energy. The *thermometer* is judiciously chosen as an example; this instrument very obviously shewing the expansive force of heat in its operation on air. Perhaps, Lord Bacon is not so happy in adducing *quicksilver*, on account of its fluidity, as a *glaring* instance leading towards the discovery of what *gravity* is; for gold, which is heavier than quicksilver, becomes fluid also by the application of heat; and quicksilver is solid at a certain temperature.

Professor Playfair adduces as an example of this class, the shells, corals, and other marine exuviæ, or their impressions, found imbedded in solid rocks, and on high mountains, as decisively proving the original formation of such land under the sea.

4. The *Instantiæ Clandestinæ*, or *obscure* instances, may be considered as opposed to the last. Bacon has also fancifully called them *Instantiæ Crepusculi*, *twilight* instances. These are the cases in which some quality or power is just beginning to manifest itself, and is in its weakest and most imperfect state. These he regards as peculiarly important in attempts at generalisation. He mentions an example with reference to the nature of *solidity*, exhibited in a low degree in a fluid, when water, blown into a bubble, assumes a kind of consistent skin, and may be thrown in this form to a considerable distance; and he infers, from such cases, that fluidity and solidity are only relative ideas, and that bodies have what he terms "a real appetite to avoid discontinuation." Water suspended in *capillary*, or very small tubes, is another illustration. This effect may be viewed when at its *minimum*, or in the least degree, that is, when the tube is increased in its bore. The column of water now becomes a slender ring, going all round the vessel. As this ring must be formed by the attraction of the sides, and of the part directly above the water, there can be no doubt that the capillary suspension arises, in part at least, from the same cause.

5. In the fifth place, are noticed the *Instantiæ Manipulares*, or *collective* instances; that is, general facts, comprehending a number of particular cases; tending to carry us to a certain extent in the discovery of *causes*, and assisting in the attempt towards a further generalisation.

The *laws of Kepler*, not mentioned by Bacon, though discovered before he wrote, are a case in point. These laws, which aided Newton in detecting the principle of *gravitation*, are three general truths or facts in astronomy; each of which holds with regard to every planet. These laws are, that the planets all move in oval orbits round the sun, placed in the common focus; that a line, supposed to be drawn from this focus, or point in the ellipse, to any planet, passes over equal spaces in equal times; and that the squares of the times of revolution round the sun are always as the cubes of the mean distances from him. Each of these laws was discovered, after vast labour and research, and by comparing together an immense number of observations. In such collective instances astronomy is fertile. A planet is seen in the heavens; by long and diligent attention, it is found to move in a certain direction, with a certain velocity, and to perform its revolution in a certain time. Hence the periodic time, or the year of every planet is a collective fact,—a fact resulting from numerous observations.

Bacon's example of this kind of instances is taken from *memory*, the nature of which is supposed to be the subject of inquiry. Collective instances, tending to conduct us some way in the investigation, are, he says, such facts as these; namely, that *order*, *artificial associations* of ideas, and *verse*, aid the memory; also whatever appeals to the *senses*, or the *passions*, so as strongly to excite them; again whatever is presented to a mind that is *free* and unoccupied, as is the case with children; what is noticed for the *first* time; and what we make an *effort* to retain—these things are usually best remembered. This instance may serve to show the comprehensiveness of Bacon's design, which was to prescribe rules for all kinds of investigations, whether relating more strictly to natural philosophy, or, as here, to intellectual science; indeed, it was in his ideas relative to the conduct of the understanding in its pursuit of truth that he chiefly excelled.

6. *Instantiæ Conformes*, or instances that are *parallel*, or analogous, are facts which resemble each other in some particulars, while in all the rest they are very different. Optical instruments and the eye; the structure of the ear, and of caverns that yield an echo, are mentioned as examples. Also the fins of fish; the feet of quadrupeds; and the wings of birds.

It was the obvious analogy between the eye and the telescope, that led to the formation of *achromatic*, or colourless glasses: the means of which invention were pointed out by observing the different refractive powers of the *humours* or lenses of the eye, which prevent the field of view from being coloured round its edges; this was successfully imitated in the telescope. On the other hand, *art* has, by a similar instance of conformity, been able to point out what takes place in nature: the experiment of the *camera obscura* led to the discovery of the image on the *retina* of the eye, by suggesting the probability of it.—Sir James Hall's experiments may be added; showing that the presence of calcareous spar, in *trap* rocks, and its absence in *lava*, may arise from the degree of compression under which the fusion of the former took place. Basalt and other trap rocks have a structure so exactly similar to the lava of volcanoes, that it could scarcely be doubted that their origin was equally derived from the agency of fire; hence the successful inquiry into the cause of the difference.—The valves in the blood-vessels of the human body resembled those used in hydraulic machines for preventing the return of the water; hence Harvey took the hint which led him to the discovery of the circulation of the blood.

7. Next are mentioned what are termed *Instantiæ Monodicæ, singular*, or irregular facts; such as are " out of course;" or are remarkably distinguished from all other instances of the class to which they belong. Examples are, the sun and moon among heavenly bodies; the magnet among stones; mercury among metals; the elephant among quadrupeds. To these of Lord Bacon may be added such instances as the newly-discovered planets, which do not move in the zodiac, and are of a much smaller size than the others; also Saturn's

ring, which is the only case we know of the kind.—Those stones called *aërolites* also, which have sometimes fallen from the heavens, may be noted as presenting a singular class of well-authenticated facts, not yet satisfactorily explained.

8. Almost the same with the last, but mentioned as distinct by Bacon, are the *Instantiæ Deviantes*, or *deviating* instances; " that is, he remarks, " errors of nature; things monstrous and uncommon, where nature turns aside from her ordinary course. These errors of nature differ from the *singular* instances, which are miracles in species; while these errors are miracles in individuals. And here the *latent process* that leads to the deviation is to be inquired into."

Examples of these are, he adds, "all prodigious and monstrous births, and productions of nature; and of all things new, extraordinary, or uncommon in the universe. And here such things are to be suspected as the prodigies of Livy; and those no less which are found in the writers on natural magic, alchemy, etc., who are the professed admirers and lovers of the fabulous."

9. *Instantiæ Limitaneæ*, or *limiting* instances, are also very near akin to the *singular*. They are those which exhibit, as it were, a combination of *two* different kinds in the same individual: the bat and the flying fish are examples; also the mole; and all combinations of different species; among these none are more remarkable than the strange quadrupeds lately discovered in New Holland, partaking of the structure both of birds and beasts, and called, by naturalists, the *Ornithorhynchus Histrix* and *Paradoxus*.

10. The next place is assigned to what are called the *Instantiæ Potestatis*, instances of *power;* by which are meant the most remarkable productions of human ingenuity; or, as they are described, " the most noble and perfect works, and such as may be called the masterpieces in every art." Here are introduced the destructive inventions of gunpowder and ordnance; the manufacture of silk; also that of paper, on which he comments with great admiration, as very singular in its texture among the productions of art. He notices also glass, porcelain, and enamel; and adds that contrivances of " dexterity, delusion, and diversion," are not wholly to be rejected from the enumeration, nor even "things magical and superstitious; charms; the supposed sympathy of spirits," etc.; because, under the falsehood of these things, the true operations of nature may oftentimes be concealed.

Of these instances, it would be endless to adduce the examples which might be furnished by the modern improvements in art and science; the *steam-engine* alone might suffice, as connected with a world of inventions, each of which would have appeared to our indefatigable author a "masterpiece of art;" witness only one of the applications of it, namely, to the working of vessels on water. But in the line with gunpowder, or rather in advantageous contrast to it, may well be placed the safety-lamp,—aptly termed by Professor Playfair, "the most valuable present that science ever made to art."

11. *Instantiæ Comitatûs, atque Hostiles*, or instances of *accompaniment* and *separation*, are those in which certain qualities, or properties, always accompany each other, and the reverse.

Of the first kind are *flame* and *heat;* that is, all flame possesses heat, while in air, stones, metals, heat is merely accidental, or may come and go. So also, excepting a very few particular cases, *heat* and *expansion* are an instance of this class; heat being accompanied with an increase of the substance in which it resides. *Body* and *gravity* may also be adduced; for whatever is impenetrable and has *inertia*, that is, everything of which we can certainly say, it is *matter*, possesses also weight, more or less.

The *hostile* instances, or those of *separation*, are opposed to the former; that is, the quality which is the subject of inquiry is always absent from them. Thus, in the case of solidity: air, and elastic fluids in general, cannot, so far as we know, assume a solid form; they are never exhibited in this state, although the discoveries of Mr. Farraday have limited the number of permanently elastic fluids by condensing, through pressure, many which were before thought incondensable. So, in the case of *transparency:* this, in solid bodies, is not found joined with malleability.

12. *Instantiæ Subjunctivæ, subjunctive* instances, or those which may be subjoined to the last, as seeming nearest to approach the exceptions to them. "As for example," says Bacon, "the mildest and softest flames, or such as burn the least; and in the subject of *incorruptibility*, of which we have no affirmative upon this earth; yet gold comes nearest to an incorruptible body."

The other examples Bacon adduces seem rather to belong to the *Instantiæ Ostensivæ*, unless he means to point them out as showing the limits of nature in some of the *accompanying* instances: "of this kind," he says, "are gold, in weight; the whale in bulk of animal body; the hound in point of scent; the explosion of gunpowder, in sudden expansion."

13. The next instances are called *Instantiæ Fœderis*, or instances of *alliance*, or *union;* in which *natures*, properties, or qualities, supposed to be dissimilar and heterogeneous, are, on investigation, found to approach nearer to each other, if not to be the very same. These, it is observed, are of great use in leading us, from resting in differences, to *genera*, or general classes. Bacon adduces his favourite subject, *heat.* He says that, in his time, the heat of the *sun*, that of *animals*, and that of *fire*, were supposed to be perfectly different in their very *natures*. He rejects this supposition, and illustrates his meaning, with regard to these instances, thus:—"we have an instance of union in the case of *grapes* ripening sooner than the grapes of the same vine out of doors, if one of the branches be trained within side a room where a fire is kept; so that culinary fire will ripen grapes, which is supposed to be peculiar to the sun's heat." He also instances the reasoning faculty in man, and the sagacity of brutes, as in some cases so nearly approaching to the appearances of originating in one common nature, as to merit particular inquiry.

14. More important than the former, are the *Instantiæ Crucis, crucial* instances; so called, after Bacon's manner, from the crosses, or way-posts used to point out roads, because they determine at once between two or more possible conclusions.

"These instances," says the author, "are of such a kind, that, when in search of any *nature* (cause), the mind comes to an equilibrium, or is suspended between two or more causes, these facts decide the question, by rejecting all the causes but one." In these cases, each of the sup posed causes equally accounts for the appearances, and it is the part of the inquirer to contrive some experiment, or discover some fact, applicable to the given question, which can only be explained by *one* of these causes; by which all uncertainty vanishes, and the true cause becomes known. It is very common to speak, both in science and common arts, of *tests* and *experimenta crucis*. These are sometimes decisive both ways, and sometimes imperfect, or what may be called *unilateral*. Thus, if a flame burns in any gas submitted to experiment, we conclude generally that there is oxygen in the air; but if it does not burn, we cannot, therefore, conclude that there is none, for it may be in too close combination with some other gas to support flame. But a perfect test would be weighing any gas; for if it be heavier than common air, in the ratio of 1.435 to 1.2, it is oxygen; if lighter or heavier it is not. Thus, too, in discussing whether a given writing be innocent or libellous, that is, maliciously composed, or composed with any improper motive of any kind, the truth is a unilateral test; for if the allegations be false, there must be malice; but there may be malice also, though the matter stated be true. There would arise very great distinctness in argumentation, were we to adopt this convenient phrase of a complete and an incomplete or unilateral test—many of the errors in reasoning, especially upon moral subjects, arising from mistaking incomplete for complete tests.

In order to illustrate this division of instances, Bacon institutes an investigation into the causes of the *tides;* but the discussion is not founded on sufficient *data;* is confused by being involved with a question upon the Copernican doctrine of the rotatory motion of the earth; and the whole terminates unsatisfactorily. To determine the true theory of the tides was reserved for Newton himself; but he did it upon the genuine principles of the Baconian philosophy.

The question whether rotation belongs to the earth, or to the heavens, generally, is also introduced; and here Bacon evidently inclines to the old hypothesis, namely, that the heavens revolve round the earth which remains at rest; though he allows that, if any comet should be observed not to obey the apparent law of the celestial motions from east to west, this would be a *crucial* instance, showing that there can exist in nature a motion contrary to the visible, diurnal motion, as it appears to the sense. This question might have been determined by observing what is called, in the language of astronomy, the motion of the planets *in latitude;* that is, their deviations from the plane of the ecliptic, or the sun's apparent annual path among what are now called the fixed stars. These deviations present a set of appearances not to be reconciled with the Ptolemaic system, which makes the earth the centre of the planetary motions, but are easily explained on the theory of Copernicus, or that of the sun being at rest in the centre. This, therefore, would have been an instance of the class before us, against the Ptolemaic hypothesis, and strongly in favour of the Copernican doctrine, though some other appearances of the heavenly bodies might accord equally well with either of the two theories.—In his remarks on the subject of gravity Bacon is more happy. He proposes to solve the question whether or not bodies tend towards the earth in consequence of an attractive power belonging to it, by ascertaining whether they fall with less velocity at greater distances from it;

and this is to be done by observing whether or not the pendulum moves more slowly at great heights above the earth's surface. Both these queries have long been satisfactorily answered.

Chemistry is rich in these *Instantiæ* or *Experimenta Crucis.* The great object in experimental philosophy is, to institute some experiment which shall be similar to another in all respects but one, which, in order to be perfectly satisfactory, the method of induction generally requires. Hence, in those branches of science in which the objects of inquiry are less completely under our command, and less capable of being put to the test of varied experiments, it is difficult to distinguish the causes; and to assign to each its own proper effect. This is often the case in *intellectual* and *moral* inquiries, in *political economy*, and also in *medicine.* Chemistry, which is so completely a science of experiment, furnishes notable instances of the present class.

The celebrated *Lavoisier* performed an experiment of this kind, which exploded the doctrine of *phlogiston*, as held by former chemists. It is well known that when metals are calcined in the fire, the weight of the mass becomes greater after the process than before. The cause of this fact was a subject of inquiry. It was supposed, from some circumstances, unnecessary to be detailed, that in the calcination of a mass of tin, for instance, a certain substance is actually driven off by the fire. To this substance, the name of *phlogiston* was given; and as the metal was heavier after its escape than before, it was supposed itself to possess what they termed absolute levity.

Lavoisier instituted the following experiment: a quantity of tin was put into a glass retort, and hermetically sealed; the retort, with its contents, was then carefully weighed. The proper degree of heat was next applied, and the metal was calcined; and now the weight was found to be exactly the same as before the process: nothing therefore could have escaped through the glass. When the retort had cooled, it was opened, and the air rushed in, showing that a partial *vacuum* had been produced. The retort and its contents were now weighed a third time, and it had gained ten grains in weight: ten grains, therefore, of air had rushed into the retort on its being opened. The *calx* was then taken out, and was found to weigh exactly ten grains more than it did before calcination. The ten grains of air, therefore, which had disappeared, and had been replaced by the same weight of air, on the retort being opened, had combined with the metal during the process. This most satisfactory experiment led to the knowledge of oxygen gas, that species of air which combines with metals when they are calcined, and the doctrine of phlogiston was exploded.

15. Next in order are *Instantiæ Divortii*, instances of *separation;* "which indicate the separation of those natures which for the most part are found together. These differ from *instantiæ crucis*, as determining nothing, but only admonishing us of the separation of one nature from another." This seems a very general distinction, and not very applicable to practice. It is followed by some curious remarks by way of illustration. Bacon says that *agency* in general belongs to some substance; but doubts whether the attraction of a magnet does not furnish an example of this agency, or virtue, being neither in the magnet nor in the body attracted, but between them both. He supposes, therefore, that "natural agency, or power," may subsist for a time

without a substance; and this he would call an *instance of separation.* He makes the same remark with regard to the attraction of the earth.

It is obvious that there is here a confusion in the use of terms; and a want of simplicity in forming the notion of *cause* and *effect. Agency* is first spoken of as a quality belonging to some agent; and afterwards as a *real existence,* independent of an agent: this would be to introduce an additional agent; and to suppose, after all, that we know more of cause and effect than we actually know, which is, that one class of events uniformly goes before another class, which may be called their corresponding events; or that a certain *antecedent* always precedes a certain *consequent.* Bacon, however, singularly founds, on these supposed instances of separation, a fanciful argument for *immaterialism,* by way of corollary, which he introduces as of great importance; alleging that "if natural virtues and agencies may subsist without a body for some time in space," this may lead us to a conception of the existence of an incorporeal substance:—its existence, however, rests on better evidence, and strictly inductive, for we know the existence of matter only by its effects on our mind through our senses, and we know the existence of mind by our consciousness, or by the reflexion of the mind itself on its own operations. We have, therefore, the same kind of evidence, in a high degree, for the existence of mind as of body.

II. *Instances tending to assist the Senses.*

The above general name is given by Lord Bacon to the five orders of instances which follow. They are called, in his usual technical style, *Instantiæ Lampadis,* instances of the *lamp,* because they propose, chiefly, to correct or inform the senses; the accurate impressions and informations of which, it is evident, are of the utmost importance in philosophical inquiries.

16. Of these five, the *first* are the *Instantiæ Januæ,* instances of the *portal,* assisting the immediate *action* of the senses, and more particularly the *sight.* Of this kind are optical instruments in general, and speaking and hearing trumpets. Bacon mentions the *telescope* as the invention of Galileo, and as bringing into view the innumerable stars of the milky way, the satellites of Jupiter, the unequal surface of the moon, and the spots in the sun; but, as he had not the opportunity of verifying these discoveries for himself, the admiration he expresses for them is tempered with some doubt as to their reality. He also notices the *microscope,* and instruments for *measuring* distances, as examples.

17. The *second* of this class are the *Instantiæ Citantes, summoning* instances; so called because they cite things, as it were, to the bar of the senses, enabling us to perceive things which were before imperceptible.

Among the causes why things escape the senses, are enumerated, *distance* of place; the *interposition* of some other body; the *unfitness* of the object to impress the senses; the shortness of the *time* during which, in some cases, the object may act on the senses; and the object, as it were, sometimes *overpowering* the senses. Whatever remedies these causes are instances in point. Bacon notices the *pulse,* as bringing to light conditions of the human frame, not cognizable by other means. He also remarks that very swift *motion* requires to be well-measured, in order to compensate for its escaping the senses;

this is now done with regard to *sounds;* and by means of the eclipses of Jupiter's moons, and the aberration of the fixed stars, the velocity of *light* itself is measured.

Other examples may be adduced from modern science: as the *barometer*, and the *air-pump*, which show the weight and elasticity of air; and the experiments in pneumatics, in general, and in electricity and galvanism, have rendered certain the existence of things, which had before entirely escaped the senses, as the *gases*, or elastic fluids. To the same head may also be reduced the late wonderful discovery of a moving magnetic fluid, or an action circular and perpendicular to the electrical current, yet connected with it.

18. *Thirdly*, follow the *Instantiæ Viæ*, instances of the *road*. "These," says Bacon, "we also term *jointed* instances, as indicating the operations of nature gradually continued; and these rather escape the observation than the senses of men." There is a propensity in men, he remarks, to be contented with viewing nature only by "fits and starts," at intervals, and when her processes are finished, while they neglect to watch her gradual method of working. This is the result of indolence. Nature's operations, however, should be carefully observed, while processes are going on, as we stand by and see the operative manufacturer carry on his work. Examples of these instances are the *vegetation* of plants; the *hatching* of eggs, throughout all their stages; such processes as *putrefaction;* and in unorganized bodies, *distillation.* These instances are somewhat similar to the *instantiæ migrantes.*

19. The *fourth* are the *Instantiæ Supplementi*, instances of *substitution*, "or those to which we have recourse," says our author, "by way of refuge, when the proper instances cannot be had." He names the *magnet*, which attracts iron through various substances which may be interposed; and adds, "perhaps some medium may be found to deaden this virtue more than any other medium; such an instance of *substitution* would be in the way of degree, or *approximation;*" that is, it would approach toward destroying the magnetic virtue. Perhaps iron has this quality in a higher degree than any other substance.

20. The *fifth*, and the last enumerated, of this class, are the *Instantiæ Persecantes*, sive *Vellicantes*, *compulsory* instances; which are thus explained. "We call them so because they *twitch* the understanding (vellicant); and because they cut through nature (persecant). They are those facts which rouse the mind to a perception of the admirable and exquisite subtilty of nature; so as that it may be awakened and stimulated to due attention, observation, and research." Bacon means, in short, those facts, which force our attention to things which are apt, from their minuteness and subtilty, to escape our observation. His remarks on these instances show how alive he was to what is curious and admirable in the laws of nature; and exhibit the genuine spirit of a philosophic observer.

Some of his examples are the following: a *drop of ink* in a pen, which is capable of so great a number of divisions into letters, in writing; the amazing length to which a *wire* may be drawn; the exquisite structure of *animalculæ;* the tincture which a little *colour* gives to a quantity of water; the small quantity of *musk* that will perfume a room, without losing any of its weight; the great volume of smoke which is extricated from some substances, as *incense;* the *notes in music*, which are so accurately conveyed through air, wood, and other mediums, and reflected so swiftly and yet so distinctly in *echoes; light* and *colour* passing so rapidly through masses of solid or fluid matter, as through glass, or water; and at the same time conveying to the eye a great and exquisite variety of images, though the light suffers refraction and reflection; the *loadstone* attracting iron through solid bodies. To these are added the multitude of natural *operations* that are going on in the universe at the same time, without interposing with each other; as, for instance, *visible objects* are seen through the air; numerous *percussions* and articulate *sounds* are acting on it; numerous *odours*, as of flowers, are passing through it; also *cold*, *heat*, and the *magnetic* attraction: all these actions are continually going on, and innumerable more without obstructing each other.

Our laborious author subjoins, what he calls *limiting* instances to this class. Thus, though one action or operation of nature does not disturb another of a *different* kind, yet this is not exactly the case with regard to actions of the *same* kind. The sound of a flute, and the smell of a rose, may both pass through the air, and make impressions on the senses at the same time; but the report of a cannon drowns the voice: the light of the glow-worm, if emitted in the sun-beams, is not visible; and a stronger odour overpowers a weaker.

III. *Instances leading to Practice.*

THIS division, to which Lord Bacon gives the general name of *Instantiæ Practicæ, practical* instances, contains those which are of principal use in practice; or in the actual effort to raise the improvement of art on the foundation of science, and thus to reduce our knowledge to some valuable purposes.

The instances of principal use in practice he regards as of *two* kinds, applicable to the two ways in which he considers that knowledge may fail of leading to actual results. This failure may be occasioned by our knowledge not being sufficiently *accurate* and precise, though sound as far as it goes; and this is often the case in natural philosophy, from objects not being exactly measured and estimated. Or the practical result that is desired may fail, through the process or experiment not being sufficiently *simplified*, but, on the contrary, encumbered and confused with operations that do not necessarily belong to it. Hence the "practical instances" are divided into two classes, of which the *first* are the *Instantiæ Mensuræ*, instances of *admeasurement;* of which he makes four kinds; and in which some estimate of the qualities and actions of bodies is to be formed, in order to remedy the first of the two above-named sources of failure; namely, the *want of precision* in our knowledge; and to aid in converting knowledge into power.

(1.) *Instantiæ Mensuræ, Instances of Admeasurement.*

21. The *first* of these are the *Instantiæ Radii*, or instances of the *measuring-rod;* that is, cases in which things are to be measured in respect of their relation to *space*. "For," says Bacon, "the forces and motions of things operate within certain spaces that are not indefinite and casual, but determinate and finite; and the due observance

of these spaces in every subject of inquiry is of great importance to practice."

He remarks, for example, that many qualities and properties act only by *contact.* In the *percussion* of bodies, motion is communicated by the impelling body touching the impelled; in the senses of *taste* and *touch* also the effect is produced by contact; so in *external remedies* used in surgery. Some agencies act at *small distances*, as in the case of *amber*, and the *magnet*, which attract certain substances within a certain sphere. Other agencies operate at *great* distances, as *heat*, *odours*, *sounds*, and especially *light*, the effects of all which, on the senses, are perceived when the sources of them are remote from us. The attraction of the *moon* on the sea is added, which Bacon thought a probable cause of the tides, though he does not seem to have considered his inquiry into the subject to have been sufficient to enable him to decide the question. Now all these agencies, it is argued, whether they take place at smaller or larger distances, are bounded and finite; and it is an object of science, to ascertain their *maxima*, or extreme limits; and how far their effects depend on the bulk and quantity of matter in the bodies of which they are the properties; on the peculiar nature of the properties or qualities themselves; or on the fitness or unfitness of the mediums through which the agencies take place. Cases also are noticed in which things act *only* beyond given distances, and never by contact; as in *vision*, where the *focus* must be attended to. These examples relate to *progressive* motions: the *expansion* and *contraction* of bodies were also to be regarded as kinds of motion, the laws and limits of which ought to be subjected to admeasurement.

The *Instantiæ Radii* may, it is evident, be illustrated further, by numerous instruments now used in experiments in natural philosophy; and the greater part of which were unknown to our author. The *thermometer*, indeed, was extant in his time, as a new invention, and furnished him with one source of his experiments on *heat*, as we have seen in the *instantiæ ostensivæ:* this instrument has been the principal means of furnishing us with what we know of the agency of heat, even up to the present time. The *hygrometer* is another instance: this instrument, which has been greatly improved by Professor Leslie, enables us to measure the quantity of moisture contained in the air. To these may be added all our instruments for measuring lines and angles, or *mathematical* and *astronomical* instruments generally: also those instruments which measure weight or force; as the common *scales*, the *hydrostatic* balance, and the *barometer*.

No part of Bacon's work is more calculated than this to show the comprehensive view he took of the agencies of nature, even when physical science was as yet in its first dawn. The instances in which bodies act on each other at a distance led him to form some confused idea of that universal principle, *gravitation*, which Newton afterwards so triumphantly demonstrated and applied. He suggests that there may be some kind of "magnetic virtue 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; or between the starry heavens and the planets, by which they may be drawn to their apogees," or greatest distances from the earth.

These *Instantiæ Radii*, which point out cases of quantities to be measured, are introduced by Bacon merely as useful in practice: they might, at the same time, have been considered as highly important, in what he terms the discovery of *forms*, or the inquiry into the natures, essences, or causes of the objects of investigation, so far forth as they may be approached. Newton found that *gravity* not only makes bodies fall to the earth, but also retains the moon in her orbit: now this could never have been shown without the previous determination of several quantities, as the law of *accelerated velocity* in falling bodies; the length of the *earth's radius* or the distance from its centre to its circumference; the *moon's distance* from the earth, and the *velocity* with which she revolves round it in her orbit. A comparison of these elements, viewed in connection with the *laws of motion*, could alone have proved that it is the same kind of force which brings a stone to the ground, and keeps the moon in her proper course. In this case, therefore, as in many others, the instances in which geometrical measures are assigned and compared, the *theory* of physics has been eminently advanced.

22. The *second* class of the instances of *measure* are termed *Instantiæ Curriculi*, instances of the *course*, in which the qualities and actions of bodies are measured by *time*. Hence Bacon also calls them *instantiæ ad aquam*, instances of the *water-glass;* alluding to the *hour-glasses* of the ancients, in which they employed water instead of sand. "For," says he, "every movement or action of nature is performed in some portion of *time;* one indeed more swiftly; another more slowly; but, all in a certain number of moments, adapted to nature. Even those actions which seem to take place in the *twinkling of an eye*, as we say, are yet different in time, as to more or less."

Familiar examples of this class are all the more obvious movements of nature, as seen in the revolutions of planetary bodies; the ebb and flow of the sea; the fall of bodies to the earth; and all animal and mechanical motions. Also the velocity of sound, as witnessed in the firing of guns, and in thunder; and of light, as exemplified by calculation of the times of the eclipses of satellites, and even more remarkably in the aberration as discovered by Bradley. The *expansions* and *compressions* of bodies also, and *explosions*, as in gunpowder, must have, in each case, their own proper *times*, if we could accurately measure them.—In many cases nature is, as it were, prevented from producing her effects, for want of due time for her operations; the hand may be rapidly passed through flame without being burned; small vessels of water may be swung round in such a manner, vertically, as not to be spilled; and a ball fired across the axis of vision is not seen, because the motion is too rapid for the eye to be impressed by it.

One passage, which occurs under this head, is too remarkable to be omitted, as presenting an anticipation of the very examples we have just adduced, though commented on afterwards by the author in a doubtful manner. "Some cases have produced in me a suspicion altogether surprising; namely, whether the face of the serene and starry heavens be seen at the very time it exists, or not till some time later; and whether there be not, with regard to the light of the heavenly bodies, a *true* time and an *apparent* time, as well as a true place and an apparent place, according to the astronomer, on account of parallax; so incredible does it seem that the rays of the celestial bodies can instantaneously pass to us, through such an immense space of miles, and not require even some considerable portion of time."

23. *Thirdly*, of the same class are the *Instantiæ Quanti*, instances of *quantity*, (literally, of how much.) These are cases in which the *virtues* or properties and effects of things are measured by the quantity of matter they contain. Examples adduced are that large collections of water do not easily become stagnant, like small ones; wines are matured and improved by being bottled off in small quantities; a magnet attracts more iron than any part of it when separated, though masses of all sizes as well as densities are equally attracted to the earth; sharp and angular points penetrate and divide bodies the most easily. The effects of *quantity*, therefore, Bacon observes, are to be carefully estimated. The importance of this to practice is obvious, if we name only chemistry and medicine.

28. The last of the four instances of measure are the *Instantiæ Luctæ;* instances of *resistance;* "which," says the author, "we also call *prevailing* instances; that is, such as show the subjection of *virtues* to one another; or which of them is the stronger and prevails, and which the weaker and submits; for the motions and struggles of bodies are no less compounded, recompounded, and complicate than bodies themselves."

In order to illustrate these *instantiæ luctæ*, Bacon introduces no less than *nineteen* kinds of *motion* (motus) or resistances, all differing, as he considers, from each other, and in their effects. He here, however, employs the word *motus* in a more general and less proper sense, than merely as signifying actual *change* of place; for in some of the cases nothing more is meant by it than certain *tendencies* in matter to resist certain external forces; thus his *Motus antitypiæ* he defines to be the resistance or repugnance which all bodies discover to the annihilation of their minute parts—it is, in short, the *indestructibility of matter;* a property which, so far as we are acquainted with nature, seems to be universal. Science may resolve matter into its component parts, or go far at least towards doing so; its form may be from the solid to the fluid, or the aëriform state; and it may combine into various ways with other matter; as may be seen in almost every chemical process, and in the dissolution of animal bodies after death: but only the Power that created matter can reduce it to nothing. To a careless observer, the fallen leaves of vegetables, which rot upon the ground, would appear to be lost for ever; but *Berthollet* has shown, by experiment, that whenever the soil becomes charged with such matter, the oxygen of the atmosphere combines with it, and converts it into carbonic acid gas. The consequence is, that this same carbon is absorbed by other vegetables, which it clothes with new foliage; these, in their turn, decay, and thus resolution and renovation go on to the end of time. In short, in the whole circle of the material world, we never witness a single instance of destruction or annihilation.

Bacon even enumerates, among these kinds of motion (motus), what is now called the *inertia* or *inactivity* of matter; a property by which it resists any change endeavoured to be made in its state, either of rest or motion; and which property is the foundation of the three *laws of motion*, as delivered by Newton in his *Principia*. Bacon singularly calls it *Motus decubitûs*, aut *motus exhorrentiæ motûs*, the *motion* (tendency) *of repose*, or *of avoiding motion*. Among the kinds of motion, or tendency, mentioned as belonging to the *Instantiæ Luctæ*, are also the following:—

Motus libertatis, the motion of *liberty;* or, as our author means, *elasticity;* that property of bodies by which they restore themselves to their original figure, after compression; as is seen in the springs of watches; air in air-guns; Indian-rubber, etc.

Motus hyles, from a Greek word signifying matter, is the capacity of *expansion;* or the tendency of matter, under certain circumstances, to enlarge its bulk: the effect of *heat*, in expanding bodies; and gunpowder in explosions, are named as familiar examples.

Motus continuationis, or the attraction of *cohesion*, by which the particles of the same mass are kept together, as forming its component parts. The modern experiments on the strength of different substances, by finding what weights are necessary in order to tear them asunder, are founded on this property. These experiments have been made with bars of wood, metals, glass, etc., of given dimensions, and it has been found that the cohesive strength of a body is in the joint proportion of its elasticity, and toughness, and the area of its section. Newton conjectured *cohesion* in bodies to be that which constitutes them of different forms and properties.

Motus indigentiæ, the motion of *preference;* or the tendency which bodies have to unite with some bodies rather than with others. Thus the surface of mercury in a *glass* bottle appears *convex*, but in a metallic vessel, it appears *concave*, in consequence of its tendency to adhere to the sides of the vessel, as it has a greater attraction for metal than for glass. Chemical attraction, or affinity, also furnishes innumerable examples. Bacon seems to confound this *elective* attraction with *capillary* attraction; from which it differs as much as it does from the attraction of cohesion, or aggregate affinity.

Motus congregationis majoris, the motion of *greater aggregation*, or, if we may distinguish it from cohesion, in modern language, the *attraction* of *aggregation*, "is that," says Bacon, "by which bodies are carried to the masses of their own natures." This may be illustrated, if we carefully observe two small globules of mercury moved towards each other along a smooth surface: their mutual attraction will be evident immediately before they unite into one globule; or, if two pieces of cork be floated in a basin of water, not nearer to its edge than to each other, they will visibly approach, and at last come into contact.

Motus fugæ, or the *motion of avoidance*, though very crudely and almost ludicrously illustrated by Bacon, has its foundation in fact, and is that property of matter which is now called *repulsion*. Newton found that a convex *lens*, when put upon a flat glass, remained at the distance of the $\frac{1}{137}$th part of an inch; and that a very considerable force was requisite to diminish this distance. Again, though steel is so much heavier than its bulk of water, yet if a dry *needle* be placed carefully upon the surface of a basin of water, it will float; the repulsion of the water preventing its sinking. Also the particles of all *gases* seem to repel each other, as appears from their elasticity. According to Boscovich, the atoms of which bodies are composed are capable of acting on each other with a force, which differs in intensity, and in kind, according to the distance. At sensible distances the force is *attractive*, and diminishes inversely as the squares of the distance. At the smallest distances the force is *repulsive;* it increases as the distance diminishes; and at last becomes infinite or insuperable. Hence if Boscovich's theory be correct, absolute contact, however paradoxical this may appear, is impossible. Facts, at all events, prove, in many cases, a repulsive power, whatever be its precise laws; and to these facts may be added, though somewhat differing from the former examples, the repulsion of electrified pith balls; also of the similar poles of two magnets. In the latter case, all the force of a strong man has proved insufficient to make the two north poles touch each other.

Motus assimilationis is the tendency of certain bodies "to convert other bodies related to them," says Bacon, "into their own substance and nature." He instances *flame*, which multiplies itself by decomposing certain substances; also animals, which seem to have a power of assimilating their food into the nature of their own bodies. However vague the notion of *assimilation* may be, Bacon's distinction here is sufficiently obvious.

To the above is subjoined *Motus excitationis*, or a tendency to *excite* and diffuse a quality. Thus *heat* diffuses itself when other bodies are heated; and the magnet gives to iron a new property without losing its own power. The distinction of this from the former *motion*, or property, lies in the circumstance of there being here no *transformation* of substances, but only a diffusion or multiplication of some virtue, or quality.

Motus impressionis, or the *motion of impression*, occurs where there seems to be a continual communication of impulses from the body which is the original source of it: the rays of light are an example, because darkness is the effect of the removal of a body from which they flow; also sounds, which cease if the vibrations of the sonorous body are suddenly stopped.

Motus pertransitionis, or *motion of passage*, has respect to the effect which the *medium* through which agencies are carried on, may have on promoting or hindering their power: thus *heat* is differently *conducted* by different bodies, or passes through them with various degrees of velocity; metals conduct it rapidly; earthy substances less so; and wood still more slowly. A ray of light, in passing from a rarer into a denser medium, as from air into water, becomes *refracted*, or is turned out of its course, and is bent towards the perpendicular. In an exhausted receiver, a bell can scarcely be heard to sound through the *attenuation* of the medium: and the experiments of Hauksbee and of Dr. Priestley show that, when the air is condensed, the sound is louder in proportion to the *condensation;* that is, in proportion to the quantity of air crowded in, and which operates as the medium of the sound, or the substance on which the vibration is first made, to be communicated through the atmosphere to our ear.

Motus rotationis spontaneus, the motion of *spontaneous rotation*, as seen in nature, is also mentioned; to which, says Bacon, belong the following considerations: the centre; the poles, or axis; the circumference; the velocity; the order, as from east to west, or west to east; the excentricity, if any, or deviation from circular motion; the declination, or the approach to, or recession from the poles; and the variation of the poles themselves, if moveable, or, in modern language, *libration*.

The other species of *motus* introduced by Bacon, under the *Instantiæ Luctæ*, are somewhat more obscure and ill-defined. *Motus nexus*, or the motion of *connection*, seems to apply to those cases in which a *vacuum* is produced, and a fluid rises in consequence of the outward pressure being taken off, as in the common pumps and the barometer. *Motus minoris congregationis*, or the motion of *lesser aggregation*, is illustrated by the *cream* of milk floating on the surface, which Bacon attributes more to the attraction which homogeneous particles have for each other, than to the specific gravity of the cream being less than that of the milk.—*Motus magneticus*, or *magnetical* motion, is applied to the attraction of the heavenly bodies, from an idea, probably, that it might be a species of magnetism.—*Motus configurationis*, aut *situs*, motion of *configuration*, or *situation*, may apply to the shooting of *crystals* into their own peculiar forms; or to the fixed tendencies of bodies to preserve the disposition of their internal parts, as their threads and fibres, and their cellular or solid structures. Bacon singularly refers hither the inquiry into the direction of the celestial motions; also the polarity of the magnetic needle.—*Motus politicus*, or the motion of *government*, is excessively fanciful and obscure: it is said to be the ruling power, or property in any body, controlling all the rest, and it "*principally reigns in the spirits of animals.*" We should scarcely suspect Bacon of *materialism*, yet he seems to have been extremely disposed to introduce mechanical causes in order to account for effects which they are entirely insufficient to explain. *Motus trepidationis*, or the motion of *trepidation*, he illustrates by the hearts and pulses of animated beings.—This long dissertation on *motions*, whatever crudities and fancies it may contain, is very curious and interesting, and we have thought it worth while to analyse it briefly, as showing on what properties in nature our discriminating author founded his distinction of *Instantiæ Luctæ*.—This class of facts might be further illustrated, were it necessary, by the instruments used in England, by Cavendish, and in France by Coulomb, for experiments on *torsion;* a term employed by the latter philosopher to denote the effort made by a thread which has been twisted to untwist itself. These instruments, by means of the force of torsion, measure very small, and almost insensible actions.

The three remaining practical instances are termed *Instantiæ Propitiæ*, or instances *propitious* to practice, in the way of immediately directing, simplifying, and facilitating it.

(2.) *Instantiæ Propitiæ, Instances facilitating Practice.*

25. Of these, the *first* are the *Instantiæ innuentes, intimating or directing* instances; that is, those which tend to free practice from useless pursuits, and direct it chiefly to such as are beneficial and advantageous to mankind; such facts in nature and in experimental science as are worthy of being attended to and pursued, because they open direct prospects of usefulness and improvement, as it respects the arts and conveniences of life.

26. The *second* of this order, Bacon terms *Instantiæ Polychrestæ;* or things that are *generally useful*, as applicable to a great variety of

investigations, by shortening and facilitating the process. To this head belong the method of conducting experiments, and the instruments and apparatus to be employed in them, which he proposed to treat particularly in a subsequent part of his work. He here notices a few general considerations which are essential to practice in a great variety of cases.

In experiments, such things are carefully to be excluded as might *disturb*, or *modify* the given process; as the common *air*, where this can be supposed to have that effect; for the same end, the matter, strength and thickness of the *vessels* in which certain processes are carried on is to be attended to; also the manner of *closing* them where they are to be closed, as by luting, or hermetically sealing, for instance; the rays of the *sun* too must often be excluded. The effects of *compression*, *condensation*, *agitation*, *extension*, *rarefaction*, etc., are to be observed in many chemical and other processes. And here Bacon's conjecture must not be omitted, that it was possible "air might be converted into water by condensation." *M. Biot*, if we mistake not, first proved this conception of our great philosopher to be true, and succeeded in forming water from hydrogen and oxygen, by *compression* only, independently of the electric spark. To these considerations are to be added that of the agency of *heat* and *cold;* and the modification these may introduce into certain experiments; also the effect produced by the *medium* through which the heat may be communicated to any substances, by the structure of *furnaces*, and by the manner in which the fire may be *applied*. Again, regard is to be had to the effect which may be produced by a process being left to go on undisturbed, and by itself, for a longer or shorter *time*. The figure, position, and situation of the vessels that are employed, are to be considered. The *sympathies* and *antipathies* of bodies, as Bacon terms them, are to be noticed where these may have an influence; of these, chemical *affinities* and *elective* attractions are obvious instances. Lastly, advantage is to be taken of what is known with respect to all the above particulars, in order, by their means, to modify, combine, and vary experiments.

27. The *third* of the instances "*propitious*" to practice, and the last of the "*prerogative*" instances, are named *Instantiæ Magicæ*, *magical* instances; and Bacon understands by this term those facts in which great and wonderful effects are produced by apparently trifling causes. Nature, he observes, "is herself sparing in these instances;" but in harmony with the very sanguine, and we fear illusory expectations which we have seen he entertained, he adds, "what she may do, when further searched and entered into, and after the *discovery of forms*, *latent processes*, and *concealed structures*, will appear to posterity." He notices as *magical* or marvellous instances, the power of *fire* to multiply itself; the effect of *poisons* on the human frame; the communication and apparent *multiplication of motion* in a set of wheels, each impelling the other; the *loadstone* animating a number of needles without loss of its own magnetic power; the origination of *motion* in explosions of gunpowder, and also of gas in mines.

Tinctured somewhat, perhaps, with the wild notions of *alchemy* then prevailing, Bacon seems to augur from such facts as the above, that wonderful things may be accomplished by human power, in "changing bodies in their smallest parts, and in all kinds of transformations." He adds, however, "of these we have hitherto no certain indications. And as in things solid, true, and useful, we aspire to the highest perfection; so we perpetually despise, and to the utmost of our power discard and reject such as are vain and empty."—Here ends the doctrine of "*Instances*" and all that was finished of the *Novum Organon* by its illustrious author.

It was Lord Bacon's design, after treating of the *instances*, of which we have now given the analysis, to proceed to the *helps* of induction; the *rectification* of induction; the method of *varying* inquiries; the prerogative *natures* for inquiry; the *limits* of inquiry, in a list of *all the natures* in the universe; the reduction of inquiries to *practice*, or to the use of mankind; the *preliminaries* to inquiry; and the *scale of axioms*, or principles.

These eight last topics were deferred, probably, till the author had found time to accumulate more materials, and they were never discussed; so that his work was left in an unfinished state. Several of the particulars, however, here enumerated are not very distinct from some of the heads already treated of, and seem to lead us back over the same ground; whence we may conclude that Bacon was fully aware that, in the existing state of the knowledge of nature and fact, in his time, his system of philosophizing could only be regarded as a sort of outline, or sketch of scientific inquiry, and needed to be worked over and over again, by way of continual approximation to truth.

What more he had to deliver on these particulars we shall not now conjecture; but it may be remarked, that by *prerogative natures* for inquiry, he seems to have intended those causes in nature, or those agencies, which present themselves as of the most obvious and prime importance, in consequence of their involving, frequently, other inquiries: thus *temperature* is so important a consideration in various experiments, especially in chemistry, that *heat* may be considered as an example belonging to the class of what are here technically termed prerogative natures. The project of making an *inventory* (*synopsis*) of *all the natures* in the universe, appears to have arisen out of our author's very sanguine ideas, as before noticed, relative to the *discovery of forms*. If by *natures* he here means *simple substances*, or those which are incapable of being decomposed by art, it is obvious that such substances may decrease in number with the progress of science. Previously to Sir Humphry Davy's distinguished researches in chemistry, the simple bodies were supposed to be about fifty in number; the facts he has brought to light, however, make it difficult to say what substances, regarded as simple, may not be capable of analysis: witness this philosopher's discovery of the metallic bases of the fixed alkalis; his decomposition of most of the earths; and his experiments on sulphur and phosphorus: all these substances were previously thought to be strictly simple.

Though no direct attempt, so far as we are aware, has been made to supply the parts of the *Novum Organon* that are wanting; nor any complete logical system founded on the same basis of induction has been published, which might serve as a perfect directory in philosophical investigations; yet there have not been wanting some efforts of a similar kind, towards promoting the advancement of the sciences, *Descartes* wrote a treatise expressly *De Methodo*, or the Method of Science, with the view of remedying the defects of the ancient plan of philosophizing, of which he seems to have been convinced. But though he flourished nearly half a century later than Bacon, and was acquainted with his writings, he pursued a course quite the contrary to that pointed out in the *Novum Organon;* which is the more singular, because, in one of his letters, he seems to acknowledge that if the experimental method of philosophizing were the true one, nothing could be superior to Bacon's rules. Descartes was anxious for a reform in the sciences; and, skilled as he was in mathematics, he was able by his genius to extend the limits of geometry as far beyond the place where he found them as Newton did after him; for he it was, principally, who developed the application of algebra to geometry, on which all modern mathematics rest; yet he was so misled by the humour of framing hypotheses, that his philosophical system is little more than an ingenious romance, and has long ceased even to be read as a matter of curiosity. In physical science, he seems never to have proposed to himself any thing like Bacon's plan of a strict *induction;* for though he did not reject experiment altogether from his philosophy, he employed it in the most loose and inefficient manner possible. He tells us that he was always able to discover *effects* by reasoning: "we employ experiment," he says, "not as a reason by which any thing is proved, for we wish to deduce effects from their causes, and not inversely, causes from their effects. We appeal to experience only, that out of innumerable effects which may be produced from the same cause, we may direct our attention to one rather than another." How different this from the tone of the very first sentence of the *Novum Organon*—MAN, THE SERVANT AND INTERPRETER OF NATURE, UNDERSTANDS AND REDUCES TO PRACTICE JUST SO MUCH AS HE HAS ACTUALLY EXPERIENCED OF NATURE'S LAWS; MORE HE CAN NEITHER KNOW NOR ACHIEVE.

It is evident that such a mode of philosophizing as this was precisely the reverse of Bacon's. Instead of proceeding upwards from effects to causes, or, as Bacon would term it, *raising axioms* from particular instances, Descartes proceeded directly in the contrary order, from causes to effects, or from generals to particulars; and this without having previously established his general conclusions in a scientific manner, or received sufficient evidence that they could be properly applied to the given particular cases. In this way he proposed to explain all the phenomena of the universe *à priori*, that is, by deducing them from his general principles by abstract reasoning; and instead of the patient caution which generally distinguished Bacon's vast analogical powers, Descartes, while he sets out with a scepticism so universal as even to make him not admit his own existence till he has attempted to prove it, at the same time exhibits, in his theories, the most unphilosophical credulity and rashness. Hence, though he certainly has the merit of great original genius in pure mathematics, his physical speculations produced the hypothesis of a *plenum* and *vortices;* or that the planetary bodies are whirled round by a subtile matter of which the universe is full; an hypothesis which, it scarcely needs be remarked, was equally applicable to all the systems of astronomy, whether that of Ptolemy, Tycho, or Copernicus; and rested upon the assumption of motions not proved to exist; or even if they did exist, just as much needing inquiry and explanation as those they are called on to solve.

M. Tschirnhausen, a member of the Royal Academy of Sciences, at Paris, published, in 1687, an essay, entitled *Medicina Mentis, sive Tentamen genuinæ Logicæ*, "Assistance to the Understanding, or an Attempt towards a genuine Logic; in which is discussed the Art of finding general Principles, and the method of discovering unknown Truths." This work, which discovers much ingenuity, is not, however, adapted to practice; and may be regarded as illustrating Lord Bacon's caution in the first book of the *Novum Organon*, with respect to the influence which particular studies may have in biassing the mind in its inquiries after truth. M. Tschirnhausen, reflecting on the little controversy there is among mathematicians, compared with the disputes among students in other branches of science, considered that a method strictly mathematical might be applied with effect to these other branches. Hence he thought that unknown truths might be discovered precisely in the same manner in every science, as in pure mathematics. He even fancies that the difference between the "perceptions of the imagination," as he terms the notions we form of things by sensation merely, and the "conceptions of the understanding," such as that a whole is greater than a part, may come under mathematical calculation! In short, by natural philosophy, Tschirnhausen seems to understand something not very different from Descartes' notion of it above mentioned, namely, a knowledge of the universe demonstrated *à priori* in mathematical order, and confirmed *à posteriori* by experiments.

At an earlier period, the *Hon. Robert Boyle* ably seconded and practically improved the plan of experimental philosophy. This distinguished man, who was born the year Bacon died, was among the first originators of the Royal Society; which was formed, in 1645, for the purpose of improving experimental knowledge on the plan laid down by Bacon. Boyle's valuable experiments in various branches of science show that he had deeply imbibed the spirit of his great master's system; and, independently of his discoveries and improvements, they constitute a most important addition to what Bacon had so loudly called on philosophers to labour at obtaining; namely, a more extensive and accurate history of nature. Many of Boyle's essays contain remarks on the method of pursuing the inquiries of science, highly calculated to facilitate and promote the grand object which Bacon pointed out, and to familiarize to philosophers the practice of an enlightened induction.

Dr. Hooke, contemporary of Boyle, a man of great mechanical science, who laid claim to several useful inventions and discoveries, and whose fame is much less than his deserts, partly because he was eclipsed by Newton, and partly because he wearied men with his inordinate pretensions, seems to have formally designed an attempt of a similar kind with Bacon's. He entitles his work "The true Method of building a solid Philosophy; or a *Philosophical Algebra*." "This," he says, consists of two parts: first, the manner of preparing the mind, and furnishing it with fit materials to work on; secondly, the rules and methods of proceeding, or operating with this so collected and qualified *supellex*." All that Dr. Hooke has left us of this posthumous piece, is little more than what Bacon has sketched in the first book of the

Novum Organon. The second part seems never to have been written, so that what the "Philosophical Algebra" was precisely to have been, must be left to conjecture.

We may safely assert, that whatever more may hereafter be done in the way of rules for scientific inquiries, can only proceed on the plan of Bacon, as the groundwork: for the method of induction is founded on the principles of human nature itself; and only needed to be fairly presented to the minds of men, generally, in order to command their approbation and support. Not, indeed, that the inductive method, as we may here take the opportunity of observing, is properly to be considered as *opposed* to the syllogistic, in which light it has been the fashion to represent it. Induction is not a distinct kind of argument from the syllogism adopted by Aristotle; that is, if by induction we understand as we ought to do, and as Bacon understands it, not merely the process of investigation, and of collecting facts, but also the deduction of *inferences* from these facts. This deduction is, of course, an argumentative process, capable, if necessary, which is, perhaps, scarcely ever strictly the case, of being put into a syllogistic form; for a syllogism is nothing more than any argument whatever, stated in order, technically, and at full length; it is an expansion of the assertions that are implied and contained in the propositions with which we commenced; and it points out the complete force of what has already been virtually admitted. The fault of the Schoolmen lay in reasoning from *false premises*, that is, in drawing conclusions from insufficient *data;* and in employing the syllogism for the purpose of making discoveries in natural science, without instituting sound philosophical inquiries.

If the real merit of a system is to be estimated by its actual effects, Bacon's *Organon*, and some of his other philosophical writings, must be reckoned among the fairest fruits which the genius of man has bequeathed to his fellows. Let the whole spirit and manner of the writings of such men as *Boyle*, *Hooke*, and *Locke*, who were Bacon's almost immediate successors, be compared with the method of those who preceded him, and it will be impossible not to perceive the commanding influence of Bacon's labours, and the very distinct character they impressed on the next age. Even Newton's incomparable genius might never have awoke to all its strength, unless Bacon had previously cleared the theatre where it was to act, and made a way for the free exercise of its energies, by removing the chief obstructions to its mighty career. The indications and the germ of several of Newton's discoveries are certainly to be detected in Bacon's works; and had Newton been born a century earlier, instead of beginning where Bacon left off, and standing on the vantage-ground reared by his labours, the world might have lost many of the most important advantages he has been able to confer on it, by means of the experimental method. Bacon scattered away the darkness of error from that horizon in which Newton was afterwards to appear, or Newton might never have had power to soar as he did into the third heavens of truth, and to pour such a flood of light over the whole field of natural science, as to excite the admiration and astonishment of his own and all succeeding ages.

Though the triumph of truth over error seems always destined to be a gradual process, it is a well-known fact that Lord Bacon's philosophical writings did not fail to make a very early impression on the learned world, both at home and abroad. The University of Oxford presented an address to him in 1623, in which he is represented "as a mighty *Hercules*, who had by his own hand greatly advanced those pillars in the learned world, which by the rest of the world were supposed immoveable." This tribute to Bacon's merit as a philosopher has the greater weight, because it was offered, as *Macvey Napier* remarks, "when all motives to interested adulation had been done away by his lamentable fall."

The Baconian philosophy seems, afterwards, to have made greater progress at Cambridge than at Oxford, notwithstanding the above testimony from the latter University to the genius of its author. "*Glanvil* lamented," says *Anthony Wood*, "that his friends did not send him to Cambridge; because he used to say, that the new philosophy, and the art of philosophizing, were more cultivated there than here at Oxford." This was about the year 1652;—Lord Bacon died in 1626. That the spirit of free inquiry in which the *Royal Society* originated, was chiefly owing to the effect of Bacon's writings cannot be disputed. For information on this subject it is sufficient to consult *Bishop Sprat's* History of the Royal Society, and *Dr. John Wallis's* account of his own life. A host of other authorities might be accumulated, were it necessary, in proof of the direct and early influence of Bacon's writings in forming the new English school; of these testimonies a great variety are collected in *Napier's* masterly tract, entitled, "Remarks Illustrative of the Scope and Influence of the Philosophical Writings of Lord Bacon."

On the continent of Europe, his philosophical reputation was early acknowledged. *Dr. Rawley* says that "his fame was greater, and sounded louder in foreign parts than at home;" and that "divers of his works had been translated, more than once, into other tongues, both learned and modern, by foreign pens." In 1652, *Lewis Elzevir* was about to publish Lord Bacon's works in Holland, as writings "long received with the most attested applause of the learned world." *Gassendi*, a strenuous opponent of the philosophy of Aristotle, and of that of Descartes, was one of Bacon's earliest disciples in France, being born in 1592. Bacon's correspondence with *Baranzan* proves how early his writings had attracted notice in Italy. We might add the testimony of *Commenius*, in Germany, so early as 1643, together with those of a number of other philosophers quoted at length by Mr. Napier, all showing that the revival of science, not only in England, but on the continent, is mainly to be traced to the effect of Bacon's writings, and this at no distant period from their publication.

That the labours of our illustrious philosopher should have excited jealousy and alarm in some quarters, and especially among those who were still devoted to Aristotle, is what we were quite prepared to expect. Error and party interest shun the light, and are ever ready to brand all attempts at improvement with the name of dangerous innovation. Perhaps no great endeavour for the welfare of mankind ever escaped this doom, or failed to rouse the tocsin of alarm. A hue and cry was accordingly soon raised against the New Philosophy, and a keen pursuit kept up, with the laudable view, if possible, of putting it down. The *Novum Organon* is now considered harmless enough surely; and in modern times, it has been permitted to slumber between its covers pretty much unmolested by the majority of mankind, who little know how greatly they are indebted to it for the effect it has had towards producing many of the arts and conveniences of life; but time was, when it was necessary to allay men's fears and jealousies of its doctrines having a sort of magic power to produce "dangerous revolutions," "subvert" governments, and overturn the authority of religion. Such, at an early period, were the alarms of not a few, and among the rest, of *Dr. Henry Stubbe*, who denounced the whole tribe of Experimentalists, with the singularly happy and courteous epithet of a "*Bacon-faced generation;*" and after informing us, in great simplicity, that he has "small regard for deep and subtle inquiries into natural philosophy," says, that "we must rise as high in our resentments" against the said generation, "as the concerns of the present age and of posterity can animate us."

So malignant an aspect, in short, did some imagine Bacon's writings to have on what are infinitely the most important interests of the human race, that *he* was shrewdly suspected of favouring *atheism*, who had eloquently published to the world, "I would rather believe all the fables in the Legend, and the Talmud, and the Alcoran, than that this universal frame is without a mind." We should have supposed that any kind of tendency to irreligion would have been the very last thing that could be imputed to Bacon's works;—but such is prejudice. It is, in fact, a happy circumstance for mankind, that geniuses the most transcendant and original that ever lighted upon our world, who have thirsted the most ardently for knowledge, and have vindicated most boldly the freedom of the human mind from every yoke but that of truth, have been the farthest from meriting such a charge, in the writings they have left us. Such were Newton, and Bacon, and Milton, and Locke.

Though we have given the *analysis* of Bacon's great work, not merely as deeming it a curiosity in the history of science, but as tending to recal our attention towards principles to which we owe so much, and the study of which we should be sorry ever to see neglected as superfluous; yet we are free to acknowledge that the whole process, according to the detail which our great philosopher recommends, was strictly necessary in practice, chiefly in the infancy of science; or, where the subject of inquiry is altogether new, and one of which we have little or no knowledge. The world, as to its improvement in science, may, in some degree, be compared to an individual. The proficient in the art of music has no need to recollect at every step the names of the notes in the *gamut*, or the rules he has been taught for fingering the keys; nor would this be possible: when he has once acquired dexterity in music as an art, theory is converted into a true, though mechanical kind of practice: so now that science has made certain advances, and has established a series of truths, it may often be quite unnecessary to go through the whole process of *induction* from the beginning. After certain general and leading principles have been completely authenticated, these may serve greatly to shorten future inquiries, and much time and labour may of course be saved. Thus, after the laws of the reflexion, and the different refrangibility of light, and the nature of the colours which refraction produces, had been satisfactorily ascertained by experiment, Newton had the materials prepared for explaining the rainbow, nor was it necessary again to institute an inquiry respecting the above laws, as if they were unknown. Newton's Optics, it may here be remarked, may justly be regarded as a most perfect specimen of the *Baconian Induction.* Dr. Black's Treatise on Magnesia Alba and Quicklime, is also an excellent model of the inductive method, affording similar examples of safely proceeding to further conclusions by assuming things well known.

It must be allowed, also, that, in addition to the effect produced by the collection of facts, and composing a history of nature, and by long practice in the experimental method, inductive investigation has been more modified in some inquiries, by the employment of *mathematical reasoning*, than Bacon, who had not pursued mathematical studies, was prepared to expect. Though he pointed out the use of mathematics, in measuring and comparing the objects of natural philosophy, he was not, nor could he be, aware to what extent geometry and analysis would be applied, in generalising inquiries, and in rendering experiment in some cases less necessary. The laws of motion, for instance, are founded, of course, on experience; but from these laws, once established, the rest of the science of mechanics is chiefly deduced by reasoning. So also in optics, when a ray of light is refracted, or bent from a straight line, as when it passes from air into water, the angle which the refracted ray makes with the surface depends on that which the incident ray makes with it; and we must ascertain by experiment what angle of refraction corresponds to any given angle of incidence; but we must have recourse to geometry if we would know the constant relation which subsists between these angles, and be able to express this relation in general terms applicable to all cases, for, with regard to this, experiment does not directly inform us. But the great triumph of mathematics, as applied to physics, and which Bacon never could have believed possible, has been the discovery of certain phenomena in the planetary motions, never suspected until the sublime discovery of modern analysis indicated those appearances as cases of the general rule.

Perhaps Bacon, moreover, in his zeal against the visionary philosophy of the ancients, scarcely allowed, in his inductive theory, the use which, in some cases, even *hypothesis* may be of in assisting our inquiries. Newton employs almost in the manner of a motto, the expression '*hypotheses non fingo,*' *I do not devise hypotheses.* He might here allude to such hypotheses as the *vortices* of Des Cartes; for he himself, in some cases, used hypothesis. In a subordinate sense of the term, and, indeed, to a limited extent, it frequently appears necessary to do so. Newton's theory of gravitation took its rise from a conjecture suggested by *analogy;* and was afterwards verified by comparing the moon's revolution in her orbit, with the law of accelerated velocity, as exhibited in falling bodies near the earth's surface. Copernicus, in the same manner, was led by *analogy* to the true system of the universe, and the only evidence he could offer in its favour was its *simplicity*. This hypothesis of Copernicus, in the hands of Newton became an established fact. Indeed, in many cases of physical investigation, there is nothing before the mind for it to act on, but two or three different hypotheses, which it is the business of a strict induction to judge of, and to adopt that which most accords with the facts.

Hypotheses become dangerous only when they are admitted as *theories*, and when, instead of being employed as a temporary guide, stimulating the mind of the inquirer to observation and experiment, they are set up as substitutes for facts, and become idols of the imagination, before which reason is to bow. It was in this view that Bacon so loudly condemned them, while it must be acknowledged that he scarcely provided for a cautious and enlightened use of them. " Any hypothesis," as Dr. Hartley well observes, " which possesses a sufficient degree of plausibility to account for a number of facts, helps us to digest these facts, to bring new ones to light, and to make *experimenta crucis* for the benefit of future inquirers."

Whatever defects or redundancies, however, the triumph of the Baconian method for two centuries has enabled us to perceive in the writings of its distinguished author, we cannot look on what he has actually done for science but with surprise and admiration. No one before him seems thoroughly to have been possessed with the idea of the folly of supposing a being of such imperfect and limited faculties as man capable of explaining nature's laws and operations by means of reasonings *à priori*. If there are beings to whom this is given, it is certainly denied to man; and the grand lesson which Bacon taught the world was, that all false philosophy might be traced to a mistake as to the real powers of the human mind, and the proper direction in which, from its nature and present condition, it must always submit to act, in the acquisition of knowledge. It had in general sought to attain to truth by eccentric movements and forced marches, while the only method suited to its capacities was looked on with contempt or disregard—that of simply feeling its way out of darkness into light. That Bacon probably overrated the effects of the inductive method, we have already remarked; this, however, was a very different thing from the ancient error of supposing the mind capable of inventing true theories without the labour of experience. It is certain that Bacon believed it within the limit of possibility to transmute other substances into gold; and on this account he has been identified with the disciples of *Raymond Lully* and *Jordano Bruno*. No one, however, could be more sensible than himself of the general folly of the pursuits of the alchemists; and his belief in *transmutation* arose out of his sanguine ideas of the resources of the inductive method—resources as yet untried and unknown; for we may venture to say that, in his time, there was not a sufficient collection of facts and experiments to authorise the conclusion that even the *essences* of different substances might not hereafter be discovered, when the new philosophy, then only in its infancy, should be matured. Time indeed has not fulfilled these anticipations, but Bacon's speculation with regard to transmutation was entertained after him by Boyle and others; and there is evidence that it was not decidedly opposed even by Newton himself.

The study of Bacon's philosophical works in general, and especially of the *Novum Organon*, cannot fail to be highly beneficial to all persons who are entering on scientific pursuits, and to all who are engaged in inquiries after truth of whatever kind. Their general tendency will be, if we do not greatly err, to inspire a habit of close and patient thinking,—an intellectual independence, which resists all that is merely of the nature of hypothesis, while it bows with implicit deference to the authority of fact and experience. The nature of the different kinds of evidence; the different subjects to which they are properly applicable; the degree of that sort of evidence that is called moral, which it is reasonable to expect in any given case; the proper limits both of doubt and of belief; the whole order of circumstances of whatever kind that may have any bearing on the impression which evidence may make, or may fail to make, on the mind;—these very interesting topics of inquiry, as well as every other subject relating to moral and intellectual philosophy, are not less properly and strictly within the sphere of the operation of the Baconian method, than the more tangible properties of matter itself, and the laws of the material universe in general. The spirit of the inductive philosophy is in perfect unison with man's intellectual nature; it offers a true corroborative to his faculties in his pursuit of truth; and the more completely this spirit is imbibed, the more shall we be guarded from the extremes of credulity on the one hand, and incredulity on the other.

Bacon's style has been condemned as "stiff and rigid;" and his wit as "often unnatural and far-fetched." He certainly employs, to a considerable degree, the quaint and highly figurative diction which was the fashion of his time. Of this we have remarkable specimens in many of his divisions in treating the doctrine of "*Instances;*" notwithstanding this, however, his style is not so often chargeable with vagueness or obscurity as might be supposed. When it is, this arises usually from his not defining his terms, from his adopting the old scholastic words and phrases with a new meaning, and employing the same word in different senses. His rich, prophetic imagination led him to the use of a lofty and poetic diction, which, though it may not altogether approve itself to a severe and philosophical criticism, often clothes his conceptions with singular beauty, embodies them to the imagination in forms of commanding energy, and impresses them deeply on the mind. His latinity in the *Novum Organon* is not to be despised; though he necessarily uses words and adopts meanings which are not to be found in the authors of classical antiquity: the subject on which he writes was new to the learned world, and he was evidently more solicitous to make himself understood, than to attain to the Augustan purity of the Roman idiom, or discourse in the music of its cadences, as we find them in Cicero's philosophical writings.

In closing this Treatise we may safely affirm, that, by giving the Inductive Philosophy to the world, Lord Bacon has proved one of its most signal benefactors; and has largely done his part towards promoting the final triumph of all truth, whether natural, or moral and intellectual, over all error; and towards bringing on that glorious crisis, destined, we doubt not, one day to arrive, when, according to the allegorical representation of that great poet who was not only the admirer of Bacon, but in some respect his kindred genius—TRUTH, though "hewn, like the mangled body of Osiris, into a thousand pieces, and scattered to the four winds, shall be gathered limb to limb, and moulded, with every joint and member, into an immortal feature of loveliness and perfection."